1996

Nesting Ecology of the White-Faced Ibis (Plegadis Chihi) in Southwestern Louisiana.

Kathleen Carson Garrett
Louisiana State University and Agricultural & Mechanical College

INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

UMI

A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor MI 48106-1346 USA
313/761-4700 800/521-0600

NESTING ECOLOGY OF THE WHITE-FACED IBIS (*PLEGADIS CHIHI*) IN SOUTHWESTERN LOUISIANA

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The School of Forestry, Wildlife, and Fisheries

by
Kathleen Carson Garrett
B.S., Ursinus College, 1969
M.S., American University, 1976
May 1996

ACKNOWLEDGMENTS

My Ph.D. program and this study of the White-faced Ibis required the assistance and cooperation of many individuals, and I wish to express my sincere appreciation to all who have contributed.

I appreciate the help of the advisors on my graduate committee: Dr. Robert B. Hamilton, my major professor and Associate Professor of Wildlife, Dr. Robert H. Chabreck, Professor of Wildlife, Dr. Robert J. Gale, Associate Professor of Chemistry, Dr. L. R. LaMotte, Professor and Head, Department of Experimental Statistics, and Dr. J. Van Remsen, Jr., Director and Curator, Museum of Natural Science and Adjunct Professor of Zoology and Physiology.

I would like to thank the U.S. Fish and Wildlife Service for permitting me to conduct my research at Lacassine National Wildlife Refuge. Specifically, I thank refuge manager Vicki Grafe and her staff for their support and for providing me with equipment and transportation--in particular Cleve Pugh, for his help in locating and monitoring waterbird colonies.

I am especially indebted to Chip Grafe for sharing his knowledge of wildlife and his tireless assistance in the field.

My very special thanks go to my husband, Lou, who provided help in so many ways (N = 1,001). I could not have completed my program or this study without his love,

encouragement, and assistance, not the least of which was serving as Director of the Alligator Surveillance and Early Alert Warning System!

I hope he continues to remind me of all his help for many years to come.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

I studied the nesting ecology of the White-faced Ibis (*Plegadis chihi*) during the summers of 1994 and 1995 in three colonies in Lacassine National Wildlife Refuge, southwestern Louisiana. Data were collected on colony-site characteristics, chronology (with abundance) of colony formation, reproductive success, and growth and development of ibis nestlings. Small colonies nested in dense buttonbush (*Cephalanthus occidentalis*) and water willow (*Decodon verticillatus*) "islands." The largest colony nested in black willows (*Salix nigra*) (3.2 ha)--a habitat unique to ibis populations in Louisiana--with nests heights up to 7.5 m. Cattle Egrets (*Bubulcus ibis*) (62%) and ibises (36%) were the most abundant species. Ibis nesting began on 23 May; hatching occurred between 19 June and 16 July. I assessed reproductive success of 292 nests with 262 chicks. In 1994 and 1995, clutches averaged 2.8 and 2.6 eggs; hatching rates (fertility) were 90% and 93%; hatching success was 41% in 1994 and 1% (in 64% of the colony) and 74% (elsewhere) in 1995; 14-day fledging success was 33% and 37%. Survival was highly correlative with hatching order: first hatched were most likely to survive. Estimated colony success was 491 fledglings from 1,292 nests (0.38) in 1994 and 149 from 622 nests (0.24) in 1995. Major environmental differences

between years were higher water, more alligators (*Alligator mississippiensis*), and fewer mammalian predators in 1994. Extensive predation by raccoons (*Procyon lotor*), mustelids, avian predators, alligators, and snakes caused most nest failures (67% and 96% each year). Minor causes included infertile eggs and collapsed and abandoned nests. Nests were more successful when substrate was black willow (vs. other tree species), over water (vs. land), in upper or lower tree heights (vs. middle), and on the edge of the colony. Nearest-neighbor species did not affect success, but nearest-neighbor distance had some effect. Measurements of the culmen, forearm, tarsus, and mass were taken of 92 chicks, the oldest was 20 days old. A chick's growth was not affected by brood size or if it survived to fledge, but was slightly affected by year and hatching order. Nestlings' regurgitated pellets contained water bugs, beetles, and horsefly and dragonfly larvae.

INTRODUCTION

BACKGROUND

The White-faced Ibis *(Plegadis chihi)* is a colonial wading bird that inhabits freshwater and saltwater marshes, ponds, rivers, wet grassy areas, and open grasslands (Hancock *et al.* 1992). Their breeding habitat is usually herbaceous marsh vegetation (often islands of emergent vegetation), bulrush (*Scirpus* spp.*), dry land, spoil islands, mangrove (*Avicennia* spp.) swamps, and inland in sagebrush (*Artemesia* spp.) and saltbush (*Atriplex* spp.) (Hancock *et al.* 1992, Ryder and Manry 1994). Feeding in shallow estuarine wetlands, flooded agricultural fields, and flooded rice fields in Louisiana, ibises consume small fish, frogs, snails, earthworms, and aquatic insects such as beetles, beetle larvae, midge fly larvae, and dragonfly nymphs (Belknap 1957, Ryder and Manry 1994).

The White-faced Ibis has two disjunct breeding populations, one in South and one in North America. The latter's range includes southern Louisiana and Texas (occasionally Florida), extends north to Alberta, Canada, west to California, east to South Dakota, and as far south as Mexico (Ryder and Manry 1994).

* Botanical scientific nomenclature conforms with Radford *et al.* (1968).

The largest breeding colonies in North America are found in the Great Basin states of Utah, Nevada, and Oregon, and in the Gulf Coast states of Louisiana and Texas, where coastal marshes provide nesting habitat (Portnoy 1977).

Locations of breeding colonies fluctuate greatly, usually in response to changing water and marsh conditions, and populations vary in their degree of philopatry, with ibises using some sites persistently but others only intermittently (Ryder 1967, Ryder and Manry 1994).

In the 1960s and 1970s, the breeding range contracted in the Great Basin states primarily because of loss of habitat to agricultural development, changing water conditions, severe drought, and pesticides (Ryder 1967, Burger and Miller 1977, Herron and Lucas 1978). Concurrent with the shrinking nesting habitat, ibis numbers declined. Ryder (1967) estimated that only 10,000 breeding pairs remained in North America in 1965. As a result of their decreasing numbers, the White-faced Ibis was classified as a "species of special concern" under the federal Endangered Species Act of 1973 (USFWS 1987, 1991, 1994). Accordingly, the U.S. Fish and Wildlife Service issued management guidelines for White-faced Ibises nesting in the Great Basin states (Sharp 1985). Through the implementation of these guidelines, the improvement of

habitat management within federal wildlife refuges, and the banning of DDT, breeding ranges have expanded and White-faced Ibis numbers have increased in those states (Ryder and Manry 1994).

Along with Mexico, Louisiana and Texas also serve as major wintering grounds, with many ibises inhabiting the coastal wetlands (Ryder and Manry 1994) and flooded rice fields farther inland (Remsen *et al.* 1991). A total of 70,080 White-faced Ibises and 6,215 *Plegadis* spp. were counted in Louisiana during the 1994 annual Christmas Bird Count (National Audubon Society 1995). Glossy Ibises (*Plegadis falcinellus*) usually compose less than 1% of *Plegadis* spp. in southwestern Louisiana. During the 1995 Christmas Bird Count, 49,950 White-faced Ibises were counted at Crowley, Louisiana, (which accounts for approximately 90% of the abundance in Louisiana) (J. Remsen pers. comm.).

Although not precisely known, numbers of breeding White-faced Ibises seem to be declining in recent years in Louisiana. Lowery (1974) wrote that "for many years" a large nesting site in southern Louisiana supported "thousands of these birds," but the "site was apparently abandoned" by the ibises. The number of known breeding adults declined from 12,495 to 6,255 between 1976 and 1990 (Portnoy 1977, Martin and Lester 1990).

RELATED RESEARCH

Almost all information related to the White-faced Ibis in Louisiana is limited to status and distribution data from Louisiana's Natural Heritage Program and the Department of Wildlife and Fisheries. Some reports include periodic atlases and censuses of wading bird and seabird nesting colonies in coastal Louisiana (Martin and Lester 1990), and others list nesting colonies of seabirds and wading birds in coastal Louisiana, Mississippi, and Alabama (Portnoy 1977, Keller *et al.* 1984).

Belknap (1957) provided pertinent details on ibises' reproductive biology, but the data analyses were limited because most field data were lost in a hurricane.

PURPOSE

Results of studies of the nesting ecology of wading birds are useful in determining local breeding habitat requirements (Maxwell and Kale 1977), in providing historical perspective to guide managers in making decisions regarding critical habitat (Parnell *et al.* 1988), and on a larger scale, serving as useful bioindicators of wetland health and ecological change (Custer and Osborn 1977, Maxwell and Kale 1977, Frederick and Collopy 1989, Kushlan 1993).

Although Louisiana is reputed to support large nesting colonies, little information is available on the nesting ecology of the White-faced Ibis in the state. In

a list of priorities for future research, Ryder and Manry (1994) strongly recommended studies of "habitat use, feeding ecology, and breeding biology" of the White-faced Ibis along the Gulf Coast.

The purpose of this research was to gather and provide comprehensive information about the nesting ecology of the White-faced Ibis in Louisiana that included: nesting chronology, abundance of nesters, habitat and nest-site preferences, reproductive biology, annual reproductive success, nestling mortality rates and causes, and nestling growth and development.

This study was performed in Lacassine National Wildlife Refuge in southwestern Louisiana during the spring and summer of 1994 and 1995. My specific objectives were to investigate:

1. Colony-site characteristics
2. Chronology of colony formation and abundance of colonial waterbirds
3. Annual reproductive success and mortality factors
4. Nestling growth and development

These topics are covered in sequence in the following four chapters.

Colony terminology follows Kushlan (1986); "colony site" is a place where nesting takes place, and "colony" is a group of birds using the site.

SITE DESCRIPTION

LACASSINE NATIONAL WILDLIFE REFUGE

Lacassine National Wildlife Refuge (LNWR) is in Cameron Parish, 11.2 km west of Lake Arthur in southwestern Louisiana (Fig. I.1). It was established in 1937 to preserve a portion (13,050 ha) of Louisiana's marshlands that provide habitat for migrating and wintering waterfowl (as many as 700,000 ducks and 200,000 geese) using the Mississippi Flyway (USFWS 1989). During the spring and summer months, as many as 60,000 marsh- and waterbirds nest and feed within the refuge. Most feed in the 6,400 ha impounded freshwater pool. Since its establishment, 228 species of birds have been observed in the refuge (USFWS 1989).

White-faced Ibises have persistently nested in the refuge for at least 4 years prior to my study (C. Parker pers. comm.). I named three major nesting sites according to their dominant vegetation: black willow (BW) (*Salix nigra*), buttonbush (BB) (*Cephalanthus occidentalis*), and water willow (WW) (*Decodon verticillatus*). Each of these plants are obligate (greater than 99% occurrence) wetland species (Tiner 1993).

BLACK WILLOW COLONY (35°00'N, 92°57'W)

This site, which supported the largest mixed-species colony of nesting colonial waterbirds, is in Unit C in the northwest corner of the refuge. White-faced Ibises

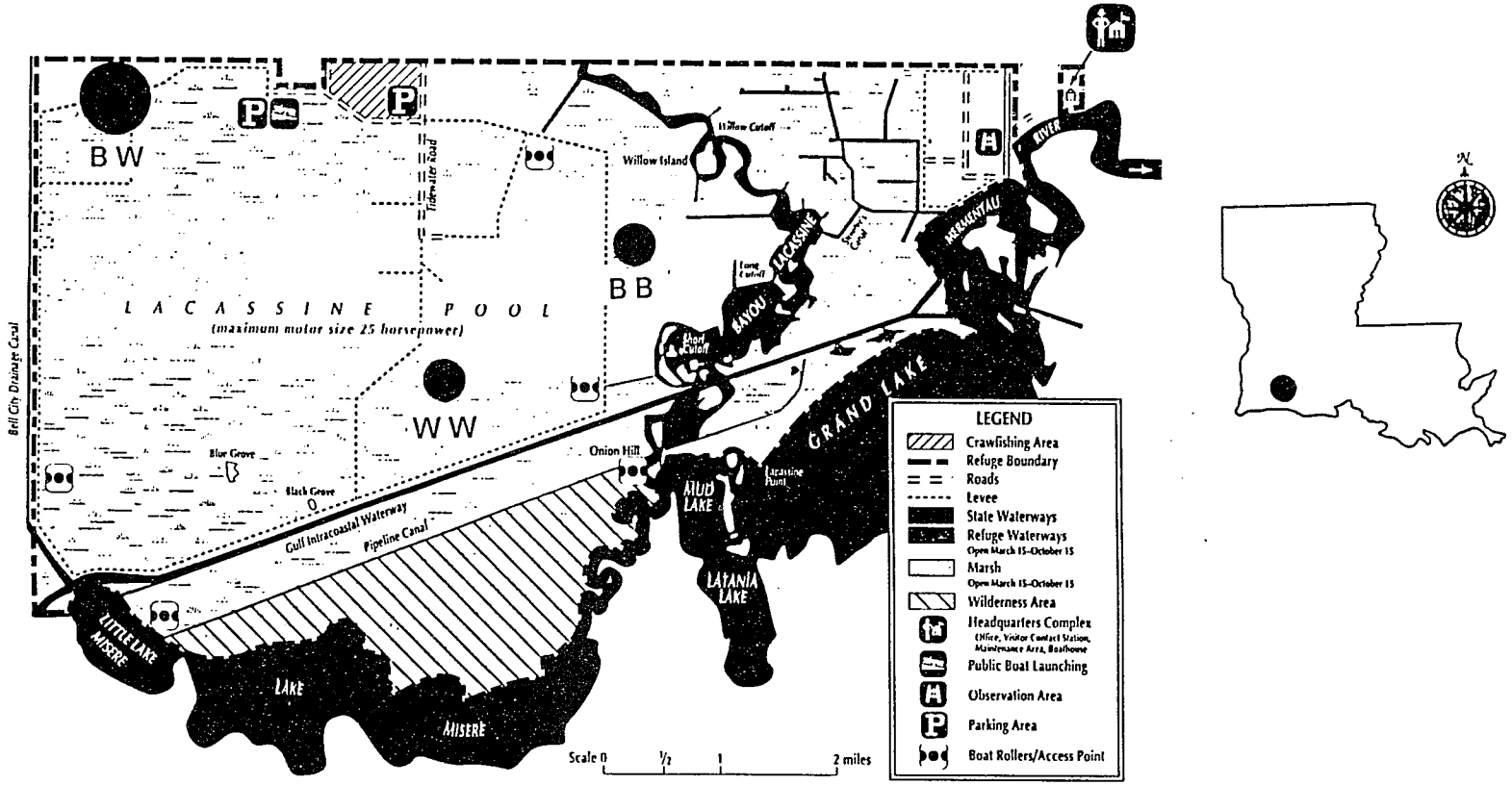


Figure I.1. Lacassine National Wildlife Refuge, Louisiana (BW = black willow colony; BB = buttonbush colony; WW = water willow colony).

composed about 35% of the colony. The site is a long narrow strip of land (3.2 ha) approximately 2.7 km long and 15 m wide. Shallow water surrounds the site on three sides, and a deep ditch about 20 m wide on the fourth side separates it from a parallel levee. Black willow trees compose approximately 92% of the overstory and are interspersed with buttonbush, tallowtrees (*Sapium sebiferum*), and elderberry (*Sambucus canadensis*). The dominant understory consists of American cupscale (*Sacciolepsis striata*) and boneset (*Eupatorium perfoliatum*). The site was accessible by truck or boat.

BUTTONBUSH COLONY ($30^{0}59'N$, $92^{0}51'W$)

This site, in the north-central section of the refuge, consists entirely of dense buttonbush. It is circular in shape, approximately 4.2 ha, and ringed by shallow water.

The shrubs are used by a series of different nesting birds throughout the summer, but White-faced Ibises were the only species present during their nesting period. We monitored this colony by airboat and from a truck parked on the levee.

WATER WILLOW COLONY ($29^{0}58'N$, $92^{0}53'W$)

This site, in the southeastern portion of the Lacassine Pool, consisted of two small adjacent circular "islands" of dense water willows (each about 0.4 ha); it was surrounded by deep water. The dominant nesting

species was White-faced Ibis, although a small number of other waterbirds were scattered throughout the colony. We accessed the site by airboat.

LITERATURE CITED

Belknap, H.W. 1957. Observations on the White-faced Ibis (*Plegadis chihi*) in Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge, LA.

Burger, J., and L.M. Miller. 1977. Colony and nest-site selection in White-faced and Glossy Ibises. Auk 94:664-676.

Custer, T.W., and R.G. Osborn. 1977. Wading birds as biological indicators: 1975 colony survey, U.S. Fish and Wildlife Service Special Scientific Report on Wildlife #206.

Frederick, P.C., and M.W. Collopy. 1989. Nesting success of five species of wading birds (Ciconiiformes) in relation to water conditions in the Florida Everglades. Auk 106:625-634.

Hancock, J.A., J.A. Kushlan, and M.P. Kahl. 1992. Storks, ibises, and spoonbills of the world. Academic Press, London. 382 pp.

Herron, G.B., and P.A. Lucas. 1978. Populations surveys, species distribution, and key habitats of selected nongame species. P-R Rep., Federal Aid Proj. W-53-R, Nevada Dept. Wildl., Reno. In Ryder, 1990.

Keller, C.E., J.A. Spendelow, and R.D. Greer. 1984. Atlas of wading bird and sea bird nesting colonies in coastal Louisiana, Mississippi, and Alabama. 1983. U.S. Fish and Wildlife Service Biol. Rep. FWS/OBS-84/13.

Kushlan, J.A. 1986. Colonies, sites, and surveys: the terminology of colonial waterbird studies. Colonial Waterbirds 9:119-120.

Kushlan, J.A. 1993. Colonial Waterbirds as bioindicators of environmental change. Colonial Waterbirds 16(2):223-251.

Lowery, G.H. 1974. Louisiana Birds, 3rd ed. Louisiana State University Press, Baton Rouge, LA. 651 pp.

Martin, R.P., and G.D. Lester. 1990. Atlas and census of wading bird and seabird nesting colonies in Louisiana: 1990. Louisiana Department of Wildlife and Fisheries, and Louisiana Natural Heritage Program. Special Report No. 3. 182 pp.

Maxwell, G.R., and H.W. Kale. 1977. Breeding biology of five species of herons in coastal Florida. Auk 94:689-700.

National Audubon Society Field Notes. 1995. Ninety-fifth Christmas Bird Count 49(4).

Parnell, J.F., and M.A. Shields. 1990. Management of North Carolina's colonial waterbirds. UNC Sea Grant Publication Number UNC-SG-90-03, University Graphics, University of North Carolina. pp. 169.

Portnoy, J.W. 1977. Nesting colonies of seabirds and wading birds in coastal Louisiana, Mississippi, and Alabama. U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-77/07. Washington, D.C. 126 pp.

Radford, A.E., H.E. Ahles, and C.R. Bell. 1973. Manual of the vascular flora of the Carolinas. The University of North Carolina Press, Chapel Hill, NC. 1183 pp.

Remsen, J.V., Jr., M.M. Swan, S.W. Cardiff, and K.V. Rosenberg. 1991. The importance of the rice-growing region of south-central Louisiana to winter populations of shorebirds, raptors, waders, and other birds. J. Louisiana Ornithol. 1:35-47.

Ryder, R.A. 1967. Distribution, migration and mortality of the White-faced Ibis (*Plegadis chihi*) in North America. Birdbanding 38:257-277.

Ryder, R.A., and D.E. Manry, 1994. White-faced Ibis (*Plegadis chihi*). *In* The Birds of North America, No. 130 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Sharp, B.S. 1985. White-faced Ibis management guidelines Great Basin population. U.S. Fish and Wildlife Service, Portland, OR. 31 pp.

Tiner, R.W. 1993. Field guide to coastal plants of the southeastern United States. The University of Massachusetts Press, Amherst, MA.

U.S. Fish and Wildlife Service. 1987. Migratory nongame birds of management concern in the United States: the 1987 list. Office of Migratory Bird Manage., U.S. Fish and Wildlife Service, Washington, D.C.

U.S. Fish and Wildlife Service. 1989. Birds of Lacassine National Wildlife Refuge. U.S. Fish and Wildlife Service. RF-43610-2. 6 pp.

U.S. Fish and Wildlife Service. 1991. Endangered and threatened wildlife and plants: animal candidate review for listing as endangered or threatened species, proposed rule. Federal Register 56:58804-58836, Washington, D.C.

U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants: animal candidate review for listing as endangered or threatened species, proposed rule. Federal Register 59:58982-59028, Washington, D.C.

CHAPTER I

HABITAT CHARACTERISTICS OF A MIXED COLONIAL WATERBIRD COLONY-SITE IN SOUTHWESTERN LOUISIANA

INTRODUCTION

The White-faced Ibis (*Plegadis chihi*) preferentially nests on short bushes, dry land, and marsh vegetation, especially tule marsh (*Scirpus* spp.), common cane (*Phragmites* sp.), and cordgrass (*Spartina* spp.) (Hancock *et al.* 1992). However, ibises have nested in the black willow (*Salix nigra*) colony in Lacassine National Wildlife Refuge for at least 4 years prior to my study (C. Parker pers. comm.), except in 1993, when shallow water surrounding the site was drained to accommodate other wildlife needs (Fig. 1.1).

This is the only study of the White-faced Ibis in which the birds nested in tall trees. Therefore, the primary purpose of this part of my study was to describe the unique characteristics of the black willow site to compare and contrast it with the more typical nesting vegetation found in other colonies, to develop historical perspective for future research, and to establish a framework for interpreting results of my related study of reproductive success.

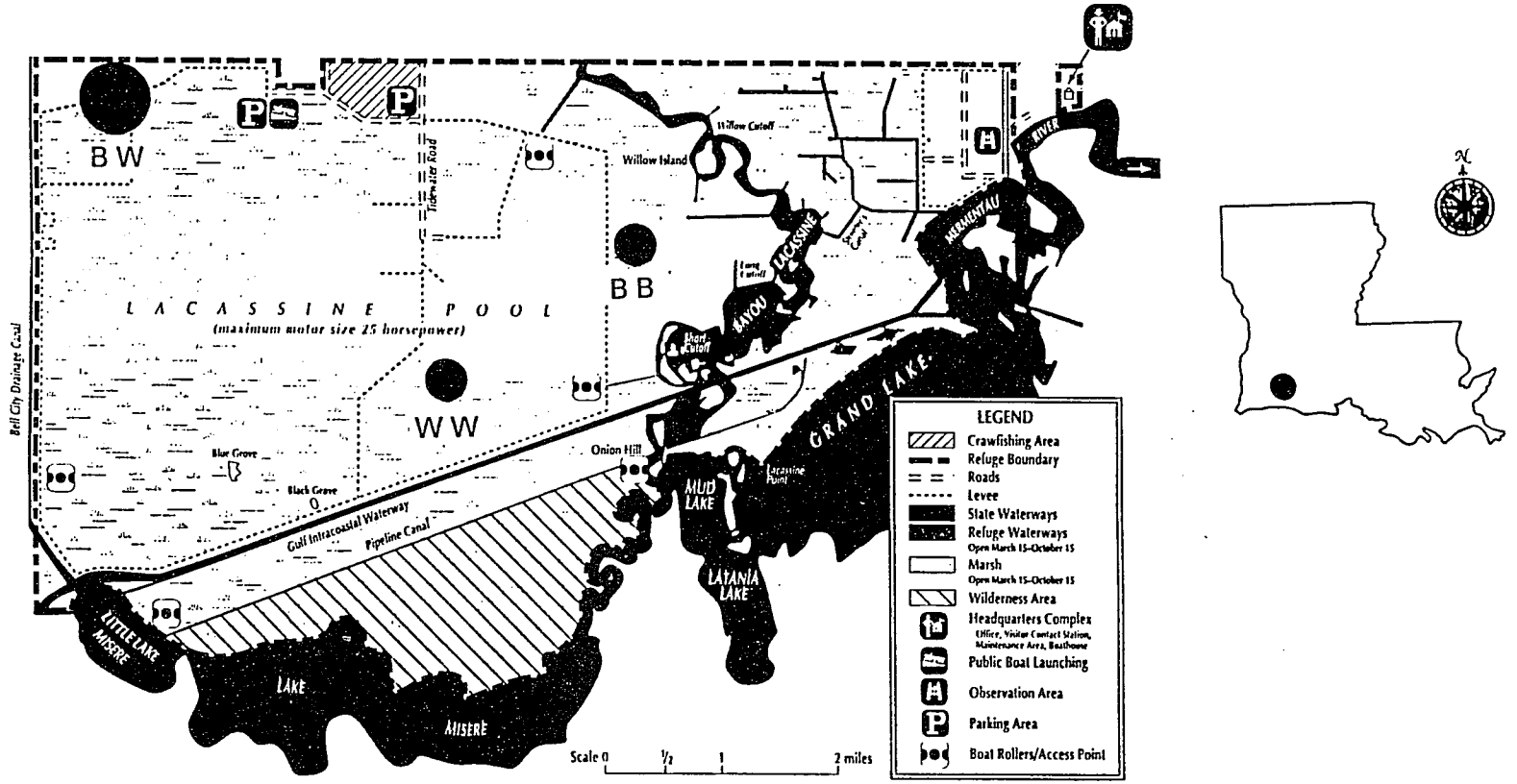


Figure 1.1. Major nesting sites of White-faced Ibises in Lacassine National Wildlife Refuge, Louisiana, 1995 (BW = black willow colony; BB = buttonbush colony; WW = water willow colony).

My specific objective in 1995 was to perform a habitat analysis of the flora and fauna in the colony-site to describe: (1) overstory and understory vegetation; (2) water level and related water-level control structures; and (3) associated predators that affected overall reproductive success of the White-faced Ibis.

METHODS

OVERSTORY

On 30 July 1995 I conducted a survey to determine overstory tree-stand composition in sections 5 through 8 and 13 through 16 at the black willow site in the refuge (Fig. 1.2). These 100-m sections had been previously randomly selected for a concurrent study of reproductive success (Chapter III).

The survey involved collecting data on relative density (percent of total vegetation) and relative dominance (size) of each plant species, number of trees per ha, basal area (area of the cross-section of a tree at breast height) per ha, and average height of the overstory.

I used the point-centered-quarter method of plotless plant sampling (Cottam *et al.* 1953, Cottam and Curtis 1956). Beginning at the western boundary of section 5, we proceeded east, collecting data at eight sites at 50-m intervals. This procedure was repeated in section 13. To aid in making calculations, we used a "point stick"

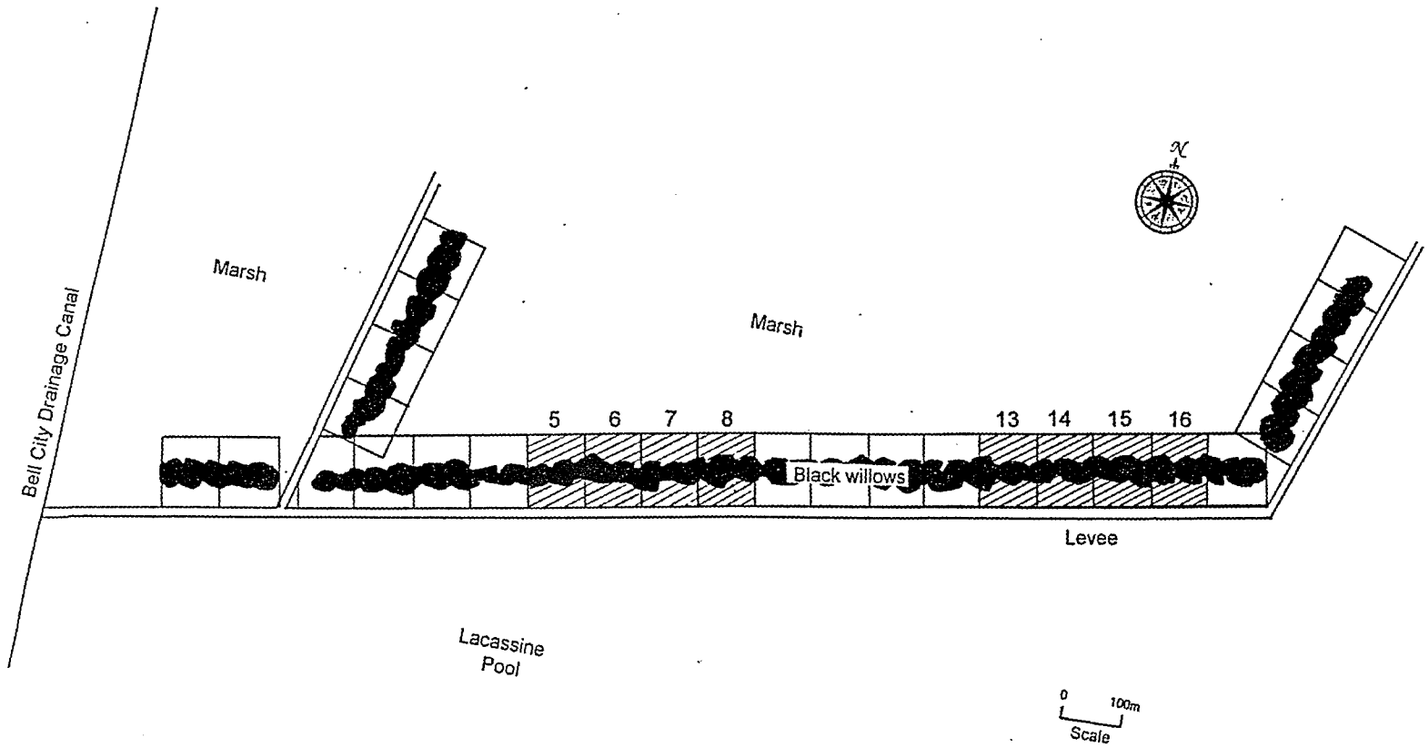


Figure 1.2. Study sections in the black willow site in which habitat analyses were conducted, Lacassine National Wildlife Refuge, Louisiana, 1995.

consisting of two wooden cross pieces, each 1 m long. One point was placed along the north-south axis and the other along the east-west axis. When the "point stick" was placed on the ground, four quadrants were created. In each quadrant, we measured the distance from "plot center" to the trunk of the nearest tree that formed part of the overstory. Three parameters--tree species, circumference at breast height in 2.5-cm intervals, and distance between tree and "plot center" (to the nearest 2.5 cm)--were recorded for the four trees selected at each site. We used a tape measure to determine circumferences and distances. Formulas used to determine tree-stand composition are listed in the Appendix.

Heights of the overstory trees were estimated with a Haga altimeter. Sixteen measurements were taken in sections 5 through 8 and 13 through 16 at the same points as those used for the overstory survey. I used the Haga altimeter to estimate the height of the highest White-faced Ibis nest in the colony, and used a ruler to measure the height of the lowest nest.

UNDERSTORY

I adapted a modified version of the Aldous Deer Browse Survey (Aldous 1944) to estimate understory abundance. On 30 July 1995, a total of 16 plot samples were taken at the same sites used to determine overstory composition. A 1.1-m rope was attached to a Jacob staff,

which was placed in the ground at each site. The extended rope formed a circle with a diameter of 2.3 m. I estimated cover (amount of ground shaded by each plant taxon) created by all vegetation less than 0.9 m tall. All cover estimates were made in 10% increments, and to maintain consistency, all estimates were made by one individual. Techniques for data collection and analysis conform with Murphy (1974). Formulas for estimating each parameter are listed in the Appendix.

WATER LEVEL

In 1994 I divided the site into 90 sections of 30 m. Four sections were randomly selected for my concurrent studies of reproductive success and chick growth (Chapters III and IV). To determine average water depth, I used those four sections and six additional randomly selected sections (Fig. 1.3). On 4 July 1995, beginning at the western boundary of each section and proceeding east, I used a ruler to measure depth at 10-m intervals for a total of four measurements per section. Average water depth was calculated by dividing the total of all measurements by 40 (the number of measurements).

The entire black willow site was above water throughout the 1995 nesting season. Using a string level, we took eight measurements at 50-m intervals in sections

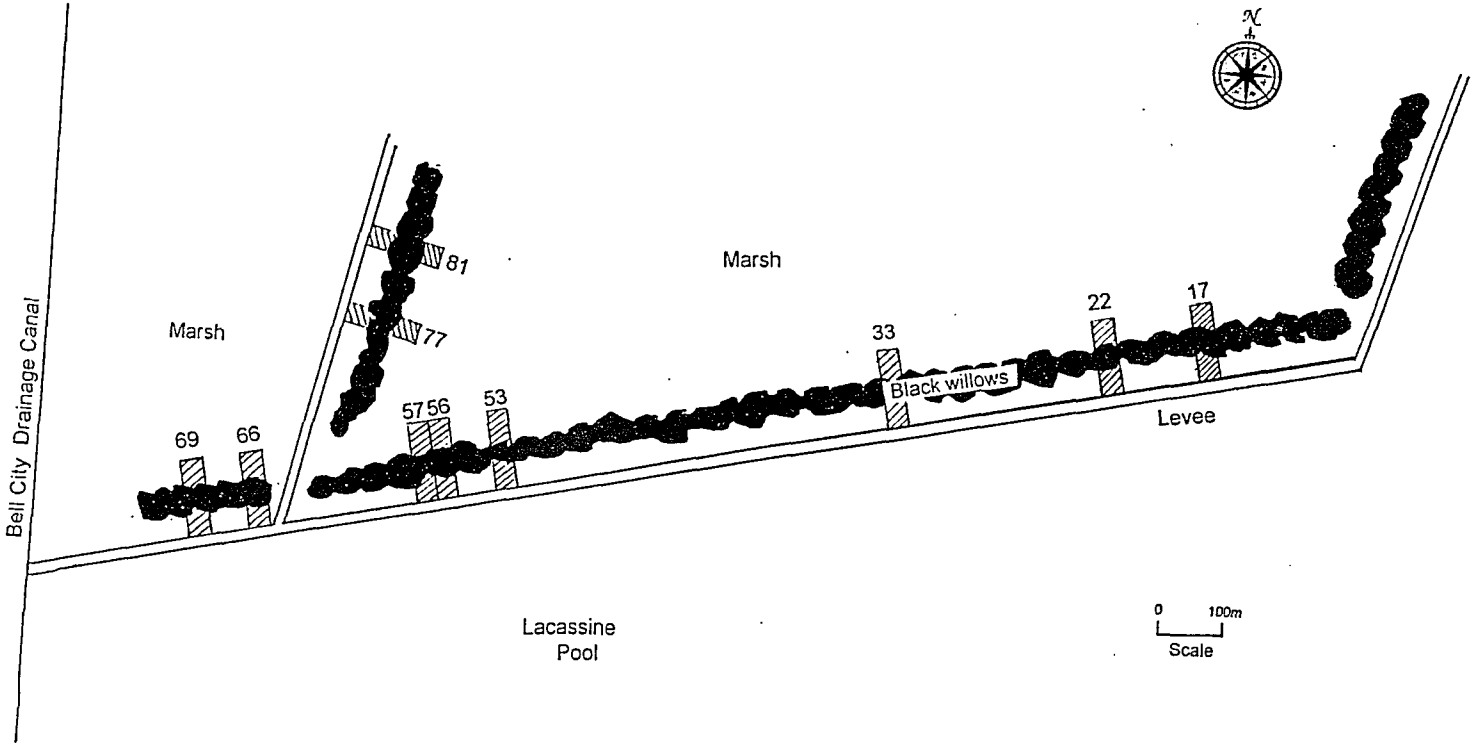


Figure 1.3. Study sections in the black willow site in which water levels were estimated, Lacassine National Wildlife Refuge, Louisiana, 1994.

5 to 8 and eight more in sections 13 to 16. To estimate the average height above water level, I divided the total of all measurements by the number of measurements (16).

ASSOCIATED PREDATORS

To help discover the cause and extent of predation within the black willow colony, I recorded the species of predators observed and the dates I saw either the animals or their signs, such as prints or scat. On several evenings we visited the colony at dusk and remained until after sunset. We watched for predators throughout the colony, on the levee, and in surrounding waters. Remaining in a truck parked on the levee, we periodically used a floodlight to detect nocturnal species or acts of predation.

On the evening of 15 July 1995, we entered the colony to record the status of each active nest. Early the following morning we returned to compare nest status with the previous night's assessments and determine the extent (if any) of overnight losses.

RESULTS

OVERSTORY

The dominant overstory in sections 5 through 8 consisted of black willows, buttonbush (*Cephalanthus occidentalis*), and tallowtrees (*Sapium sebiferum*) (Table 1.1). Black willows were the most abundant species (84%), and their relative dominance (size) was 94%. There

Table 1.1. Forest-stand overstory composition in sections 5 through 8 and 13 through 16 of the black willow site, Lacassine National Wildlife Refuge, Louisiana, 30 July 1995. Formulas are listed in the Appendix.

Sections 5-8

Taxon	No. of trees sampled	Relative density %	Relative dominance %	Avg. dbh (cm)	No. of trees per hectare	BA per hectare
Black willow	27	84	94	13.7	746	11.0
Buttonbush	3	9	1	2.0	79	0.1
Tallowtree	2	6	5	12.2	54	0.6

Sections 13-16

Black willow	32	100	100	18.0	405	10.3

were approximately 746 trees per ha, and the basal area was 11.0 m^2 per ha.

Buttonbush made up 9% of the overstory, with 1% relative dominance, and tallowtrees, the least abundant species (6%), had a relative dominance of 5%.

In sections 13 through 16, black willow trees made up 100% of the overstory. There were 405 trees per ha, and the basal area was 10.3 m^2 per ha.

Height of the overstory in sections 5 through 8 averaged 9.4 m and ranged from 4.6 to 12.8 m. Overstory in sections 13 through 16 averaged 9.3 m in height with a range of 7.3 to 11.6 m. Nest heights ranged from 0.9 to 7.5 m.

UNDERSTORY

Fourteen taxa were found within the eight plots sampled in sections 5 through 8 (Table 1.2). The most abundant taxa were American cupscale (*Sacciolepis striata*) (21%), boneset (*Eupatorium perfoliatum*) (18%), Mosquito-fern (*Azolla caroliniana*) (13%), and smartweed (*Polygonum punctatum*) (10%). The remaining 10 plant taxa accounted for 38% of all vegetation.

Seven taxa were found in sections 13 through 16 (Table 1.3). Boneset and American cupscale occurred in all eight plots and comprised 93% of all vegetation.

Table 1.2. Understory vegetation in sections 5 through 8 at the black willow site, Lacassine National Wildlife Refuge, 30 July 1995. Data are presented in descending order by percent of total vegetation. Formulas are listed in the Appendix.

Taxon	Frequency(%)	Average Cover	% of Total Vegetation
Sacciolepis striata	0.75	22.5	0.21
Eupatorium perfoliatum	0.88	19.38	0.18
Azolla caroliniana	0.38	13.75	0.13
Polygonum punctatum	0.75	11.25	0.10
Alternanthera philoxeroides	0.50	10.0	0.09
Mikania scandens	0.75	8.13	0.07
Hydrocotyle canunculoides	0.50	6.88	0.06
Rubus sp.	0.38	3.75	0.03
Sambucus canadensis	0.25	3.75	0.03
Cephalanthus occidentalis	0.75	3.75	0.03
Phytolacca americana	0.25	3.13	0.03
Nelumbo lutea	0.25	0.63	0.01
Sesbania exaltata	0.38	1.25	0.01
Sapium sebiferum	0.25	0.63	0.01

Table 1.3. Understory vegetation in sections 13 through 16 at the black willow site, Lacassine National Wildlife Refuge, 30 July 1995. Data are presented in descending order by percent of total vegetation. Formulas are listed in the Appendix.

Taxon	Frequency(%)	Average Cover	% of Total Vegetation
Eupatorium perfoliatum	1.0	62.5	0.48
Sacciolepis striata	1.0	58.1	0.45
Phytolacca americana	0.25	2.5	0.02
Mikania scandens	0.63	3.1	0.02
Cephalanthus occidentalis	0.25	1.3	0.01
Polygonum punctatum	0.25	1.3	0.01
Nelumbo lutea	0.25	0.6	0.004

WATER LEVEL

During the summer of 1994, the bases of 96% of the black willow trees in the colony-site were underwater throughout the nesting period. Water depth averaged 33 cm. In 1995, however, the entire colony-site was dry, and nest-trees were an average of 41 cm above the water level.

ASSOCIATED PREDATORS

We saw a variety of predators capable of depredating eggs, chicks, or both. Terrestrial species observed in or near the colony included raccoon (*Procyon lotor*) and mink (*Mustela vison*). Also, rat snakes (*Elaphe obsoleta*), cottonmouths (*Agkistrodan piscivorus*), American alligators (*Alligator mississippiensis)*, and fire ants (*Solenopsis* spp.) were abundant. Aerial predators in or near the colony included the Yellow-crowned Night-Heron (*Nycticorax violaceus)*, Black-crowned Night-Heron *(Nycticorax nycticorax)*, Boat-tailed Grackle (*Quiscalus major*), and a Great Horned Owl *(Bubo virginianus*).

Results of our evening and subsequent morning comparison of nest status enabled us to determine nocturnal losses. There were 52 active nests when we entered the colony at dusk on 15 July. Four nests contained one egg, one contained two eggs, and one had three eggs. Fifty nests had at least one chick.

The following morning we found that the status of five eggs had changed. Two eggs had hatched and the three-egg nest had been depredated. Eggshells were spread throughout the depredated nest.

A total of five chicks ranging from 4 to 10 days old were missing from 4 of the 50 nests with hatchlings. Two chicks in two other nests had been depredated. The bill of one chick, and the head of the other, had been eaten. The first chick was 8 days old and the second was approximately 12 days old. That morning we also found the remains of two Cattle Egret (*Bubulcus ibis*) chicks and one White-faced Ibis chick on the ground near the study nests.

DISCUSSION

OVERSTORY AND UNDERSTORY

In other studies of the breeding biology of ibises researchers have found that the White-faced Ibis preferentially nests in "herbaceous marsh vegetation, although it will nest on short bushes, on dry land, and on spoil islands" (Hancock *et al.* 1992). Despite the availability of the more typical nesting vegetation in the refuge, the largest colony nested in black willow trees (Chapter II): a habitat unique to ibises nesting in southwestern Louisiana. These trees were as high as 12.8 m, and nests ranged from 0.9 to 7.5 m in height, much higher than those found in previous studies.

White-faced Ibises have been reported to nest in a variety of vegetation. Previously in Louisiana, White-faced Ibises have been observed nesting in smooth cordgrass (*Spartina alterniflora*) along the coast (Portnoy 1977). In Lacassine they have nested in bulrush (*Scirpus* spp.), low buttonbush, and Roseau cane (*Phragmites australis*) in nests between 51 and 137 cm above the water surface (Belknap 1957). Belknap observed only White Ibises *(Eudocimus albus*) nesting in the black willows that occurred throughout Lacassine, indicating that White-faced Ibises in the refuge began nesting in the black willows within the last 39 years.

Bulrush was the preferred nesting vegetation in Utah (where nest heights ranged between 20.2 and 99.0 cm above water) (Kotter 1970, Kaneko 1972, Alford 1978), Colorado (54.1 cm above water) (Schreur 1987), and Oregon (Henny and Herron 1989). Cattails (*Typha* sp.) were a less common site in Utah (with an average nest height of 35.8 cm) (Alford 1978) and Colorado (Schreur 1987). Deserted muskrat (*Ondatra zibethica*) lodges were occasionally used in Utah (Kotter 1970), and nests in California were built in Baltic rush (*Juncus balticus*) and summer tamarisk (*Tamarix pentandra*) (Ivey and Severson 1984). Texas sites included sea ox-eye *(Borrichia frutescens*) and mixed forbs with nests an average of 19.3 mm above ground (Burger and Miller 1977).

Use of black willows as nesting sites by the White-faced Ibis seems to be unique to southwestern Louisiana. The black willows and their surrounding habitat apparently fulfill the nesting requirements of ibises because (with the exception of 1 year) they have returned to nest there for at least the last 6 years.

WATER LEVEL

The study site was in an impounded freshwater marsh surrounded by levees. Water depth was regulated and manipulated through an adjustable control structure consisting of a screwgate and a variable crest weir. The refuge managers can drain water from the impoundment but not add it to the impoundment. Water levels could be raised by preventing rainwater from draining from the area. Regulating water levels in the impounded marsh is one aspect of the refuge's marsh management program that enables personnel to control the type and growth of aquatic vegetation for the benefit of various wildlife species (Chabreck 1981).

During the summer of 1994 the screwgate remained closed and rainwater was retained in the impoundment. At the peak of nesting the water depth averaged 33 cm in 96% of the site. In 1995 the screwgate was partially open. As a result, water drained from the impounded area into the nearby Bell City drainage ditch, and the colony-site was dry throughout the nesting season.

In both years, water surrounded the site, but water levels within the site varied. The change in water level may explain an apparent difference in the abundance of alligators each year. Although we did not count alligators each year, for safety reasons we were continually alert to their presence. In 1994, when water depth averaged 33 cm in the colony, more alligators were in and around the site than in 1995, when the site was dry. Also, larger alligators moved into the colony-site as the 1994 nesting season progressed.

The colony suffered less predation in 1994 when water levels were higher (Chapter III). There may have been a critical interaction between water levels, alligators, and mammalian predators. This relationship is discussed in more detail in Chapter III).

ASSOCIATED PREDATORS

Although acts of predation were seldom witnessed, results of previous studies as well as the physical evidence we observed (eggshells, tracks, scat, types of injuries, etc.) confirmed the presence of terrestrial and aerial predators in the colony.

Predators were a major cause of nest failures in the colony (Chapter III) and should not be overlooked as a major facet of nesting ecology. Therefore, I discuss them in more detail below.

The raccoon diet includes both bird eggs and nestlings (Whitaker 1980). Raccoons are excellent climbers (Lowery 1974) and have caused extensive destruction of nesting colonies (Lopinot 1951, Burger and Hahn 1977, Southern and Southern 1979). On two occasions, one during the day and the other at night, we observed a raccoon on the levee directly opposite our study sections. In addition, we saw raccoon tracks throughout the colony and, on one occasion, found raccoon scat in a depredated nest.

Mink eat birds and occasionally bird eggs (Lowery 1974). They consume "marsh dwelling birds" after "killing victims by biting them in the neck." Prey are eaten where taken or carried to their den. Mink "swim well" and "can climb trees--though they do so rarely" (Niering 1985). In 1995 I briefly observed one mink on the ground in the colony.

The diet of the Black-crowned Night-Heron includes eggs and young birds, especially those of terns, herons, and ibises (Ehrlich *et al.* 1988). Nestling Black-crowned Night-Herons "are notorious for their habit of eating the nestlings of other wading birds. Almost as soon as nestling night-herons are ambulatory, usually at about 2 to 3 weeks of age, they begin to walk through the colony, looking for unattended young. Nestlings of this species are the ultimate ground-based nursery bullies"

(Bildstein 1993). Bildstein observed Night-Herons consuming Snowy Egret (*Egretta thula*) chicks and those of other wading birds, and they have also been seen eating White Ibis chicks in colonies where they were nesting (Frederick and Collopy 1989). Four pairs of Black-crowned Night-Herons nested within the black willow colony. During one dark afternoon, while delayed by rain, we observed an adult stalking through previously depredated nests.

Yellow-crowned Night-Herons also consume young birds; like Black-crowned Night-Herons, their "larger bill permits larger prey than similarly sized herons" (Ehrlich *et al.* 1988). Sixteen pairs nested in the black willow colony.

Boat-tailed Grackles, prevalent throughout the colony, consume both bird eggs and nestlings (Ehrlich *et al.* 1988). Egret eggs were opened and eaten by Boat-tailed Grackles in a Florida heronry (Jenni 1969).

Great Horned Owls are predators of young nestlings (Pratt and Winkler 1985). We observed one in the refuge, near the colony.

Fire ants were widespread in the site. They entered through pipped egg openings and consumed two chick embryos. Similarly, Burger and Miller (1977) discovered fire ants invading White-faced Ibis eggs in Texas via pipped openings.

Rat snakes consume eggs and constrict and consume small birds (Halliday and Adler 1986, Conant and Collins 1991). They are arboreal snakes that climb well because of angles in their belly scales that enable them to grip irregularities on bark. We observed a rat snake in a study nest that contained two chicks.

Alligators ranging in length from 1 to 4 m were prevalent throughout the site. Birds are a consistent part of their diet in nearby Sabine National Wildlife Refuge (Valentine *et al.* 1972). On five occasions Jenni (1969) watched an alligator "catch and eat" Cattle Egret chicks in a Florida heronry.

We saw several alligators stalk adult ibises feeding in water directly below their nests and witnessed alligators catch and consume an adult Anhinga (*Anhinga anhinga*) and a Cattle Egret chick. On one occasion an alligator was seen splashing back into the water with the remains of a nest in its jaws.

Belknap (1957) saw no alligators in or near the small island in Lacassine where his study took place. He attributed their absence to persistent hunting of alligators for their hides. Because of regulated hunting during my study, alligators were more numerous. Also, according to the refuge's wildlife enforcement officer, hunting is not permitted in Unit C where the black willow colony was located (C. Pugh pers. comm.).

Comparisons of nest status late one evening with status early the following morning implicated several predators. Scattered eggshells were an indication of raccoon predation. The consumed chicks implicated mammalian predators such as mink or raccoon, and mink were the most likely predators of the chicks with partially consumed bill and brains. Missing chicks may have been taken by owls, Black-crowned Night-Herons, snakes, mink, or raccoons.

It is apparent from the various signs of predation that a combination of aerial and terrestrial predators detrimentally affected the reproductive success of the colony.

LITERATURE CITED

Aldous, S.E. 1944. A deer browse survey method. J. Mammal. 25(2):130-136.

Alford, E.H. 1978. Early nesting by White-faced Ibis in relationship to habitat: an adaptive advantage. M.S. Thesis, Brigham Young University, Provo, UT. Unseen.

Belknap, H.W. 1957. Observations on the White-faced Ibis (*Plegadis chihi*) in Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge, LA.

Bildstein, K.L. 1993. White Ibis: wetland wanderer. Smithsonian Institution Press, Washington, D.C.

Burger, J., and C. Hahn. 1977. Crow predation on Black-crowned Night-Heron eggs. Wilson Bull. 89:350-351.

Burger, J., and L.M. Miller. 1977. Colony and nest-site selection in White-faced and Glossy Ibises. Auk 94:664-676.

Chabreck, R.H. 1981. Effects of impoundments in marshes on wildlife and fisheries. Pp. 21-29. In R. C. Carey and J.B. Kirkwood, eds., Proceedings of the U.S. Fish and Wildlife Service Workshop on Coastal Ecosystems of the Southeastern United States. Washington, D.C.: U.S. Fish and Wildlife Service, Biological Service Program FWS/OBS-80/59.

Conant, R., and J.T. Collins. 1991. A field guide to reptiles and amphibians of eastern and central North America. Houghton Mifflin Company, New York, NY. 450 pp.

Cottam, G., and J.T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecology 37(3): 451-460.

Cottam, G., J.T. Curtis, and B.W. Hale. 1953. Some sampling characteristics of a population of randomly dispersed individuals. Ecology 34(4):741-757.

Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. The birder's handbook: a field guide to the natural history of North American birds. Simon and Schuster, Inc., New York, NY. 785 pp.

Frederick, P.C., and M.W. Collopy. 1989. The role of predation in determining reproductive success of colonially-nesting wading birds (Ciconiiformes) in the Florida Everglades. Condor 91:860-867.

Gill, F.B. 1990. Ornithology. W. H. Freeman and Company, New York, NY. 660 pp.

Halliday, T.R., and K.A. Adler. 1986. The encyclopedia of reptiles and amphibians. Facts on File, Inc., New York, NY. 143 pp.

Hancock, J.A., J.A. Kushlan, and M.P. Kahl. 1992. Storks, ibises, and spoonbills of the world. Academic Press, London. 382 pp.

Henny, C.J., and G.B. Herron. 1989. DDE, selenium, mercury, and White-faced Ibis reproduction at Carson Lake, Nevada. J. Wildl. Manage. 53:1032-1045.

Ivey, G.L., and D.J. Severson. 1984. White-faced Ibis nesting in the southern San Joaquin Valley of California. Condor 86:492-493.

Jenni, D.A. 1969. A study of the ecology of four species of herons during the breeding season at Lake Alice, Alachua County, Florida. Eco. Monogr. 39:245-270.

Kaneko, K.D. 1972. Nesting of the White-faced Ibis (*Plegadis chihi*) on Utah Lake. M.S. Thesis, Brigham Young University, Provo, UT.

Kotter, B.L. 1970. An ecological natural history of the White-faced Ibis (*Plegadis chihi*) in northern Utah. M.S. Thesis, University of Utah, Salt Lake City.

Lopinot, A.C. 1951. Raccoon predation on the Great Blue Heron, *Ardea herodias*. Auk 68:235.

Lowery, G.H. 1974. Louisiana Birds, 3rd ed., Louisiana State University Press, Baton Rouge, LA. 651 pp.

Murphy, P.K. 1974. The monthly availability and use of browse plants by deer on a bottomland hardwood area in Tensas Parish, Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge.

Niering, W.A. 1985. The Audubon Society Nature Guides. Wetlands. Alfred A. Knopf, Inc. New York, NY.

Portnoy, J.W. 1977. Nesting colonies of seabirds and wading birds in coastal Louisiana, Mississippi, and Alabama. U.S. Fish and Wildlife Service, Biological Services Program FWS/OBS-77/07. Washington, D.C. 126 pp.

Pratt, H.M., and D.W. Winkler. 1985. Clutch size, timing of laying, and reproductive success in a colony of Great Blue Herons and Great Egrets. Auk 102:49-63.

Radford, A.E., H.E. Ahles, and C.R. Bell. 1973. Manual of the vascular flora of the Carolinas. The University of North Carolina Press, Chapel Hill. 1183 pp.

Schreur, J.L. 1987. Ciconiiformes reproductive success and public viewing in the San Luis Valley, Colorado. M.S. Thesis, Colorado State University, Fort Collins.

Southern, L.K., and W.E. Southern. 1979. Absence of nocturnal predator defense mechanisms in breeding gulls. Colonial Waterbirds 2:91-101.

Valentine, J.M., Jr., J.R. Walther, K.M. McCartney, and L.M. Ivy. 1972. Alligator diets on the Sabine National Wildlife Refuge, Louisiana. J. Wildl. Manage. 36(3):809-815.

Whitaker, J.O. 1980. The Audubon Society field guide to North American mammals: eastern region. Alfred A. Knopf, New York, NY. 745 pp.

CHAPTER II

NESTING CHRONOLOGY AND ABUNDANCE OF THE WHITE-FACED IBIS AND OTHER COLONIAL WATERBIRDS IN LACASSINE NATIONAL WILDLIFE REFUGE, LOUISIANA, 1995.

INTRODUCTION

Historically, large colonies of White-faced Ibises (*Plegadis chihi*) have nested in Louisiana (Portnoy 1977), but their numbers seem to be declining. The number of breeding adults found in Louisiana decreased from 12,495 to 6,255 between 1976 and 1990 (Portnoy 1977, Martin and Lester 1990). In contrast, ibis populations nesting in the western United States seem to be increasing (Ryder and Manry 1994).

Little is known about nest-site preferences of ibises in Louisiana; in the only previous study, Belknap (1957) found colonies in Roseau cane (*Phragmites australis*), bulrush (*Scirpus* spp.), and low buttonbush (*Cephalanthus occidentalis*)--typical nesting vegetation of the White-faced Ibis (Ryder and Manry 1994).

Lacassine National Wildlife Refuge has diverse nesting habitats, and in recent years the White-faced Ibis has been observed nesting not only in buttonbush, but also in black willow (*Salix nigra*) trees (Fig. 2.1). In 1995

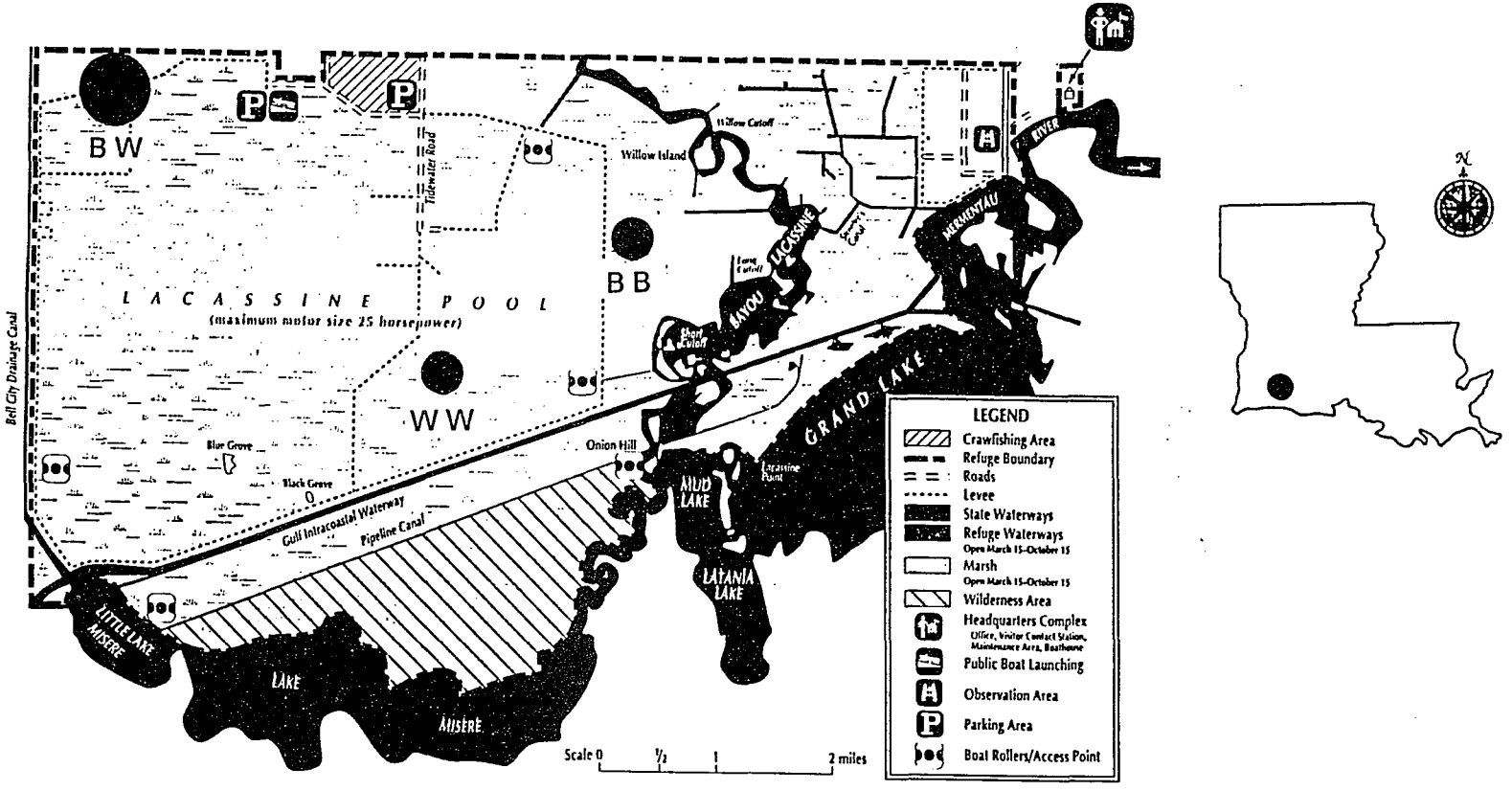


Figure 2.1. Major nesting sites of White-faced Ibises in Lacassine National Wildlife Refuge, Louisiana, 1995 (BW = black willow colony; BB = buttonbush colony; WW = water willow colony).

they also nested at a third site consisting entirely of water willows (*Decodon verticillatus*).

Because of the decline in nesting numbers and the lack of knowledge about their preferred nesting habitats in Louisiana, my primary objective was to determine the chronology of nesting and the abundance of White-faced Ibises in each physiognomically homogeneous habitat in the refuge. A second objective was to document the abundance of other species, and to determine to what extent nesting cycles of other species, especially Cattle Egret (*Bubulcus ibis*) overlapped that of the White-faced Ibis--an occurrence that might create competition for nest-sites and materials.

METHODS

STUDY SITE

To achieve my objectives, I planned to study nesting chronology and abundance in the two sites of greatest nesting activity in the refuge, namely the black willow and buttonbush sites. In addition, in March, 1995, we began looking for other ibis colonies in the refuge and surrounding wetlands. Searches were conducted by truck, airboat, and fixed-wing aircraft.

During an aerial search in May, we discovered a colony of ibises nesting in black willow trees approximately 6 km west of the refuge. This site was on private property, and I was unable to gain permission to

enter it to study the birds. We estimated that the colony consisted of 300 to 400 nesting pairs of ibises.

On 18 May 1995, during an airboat search of the refuge, we discovered a colony of approximately 50 ibises nesting on two small (75 m diameter) adjacent "islands" of water willow (Fig. 2.1). Water willows (or water loosestrife), also referred to as swamp loosetrife (Tiner 1993), grow in deep water and form dense clusters or "islands." Like black willows and buttonbush, the water willow is an obligate (greater than 99% occurrence) wetland species (Tiner 1993).

After discovering this colony, we made several follow-up visits to observe nesting progress, but because it was accessible only by airboat, we were unable to monitor it regularly.

FIELD METHODS

1994

Nesting was already in progress when I began the study, and I was therefore unable to determine nesting chronology.

To determine abundance, we conducted a census on 4 July. We counted all active nests in the colony for each species except Cattle Egret. To estimate abundance of Cattle Egrets, I extrapolated data from the same 10 sections used to estimate water level (Chapter I) (Fig. 2.2).

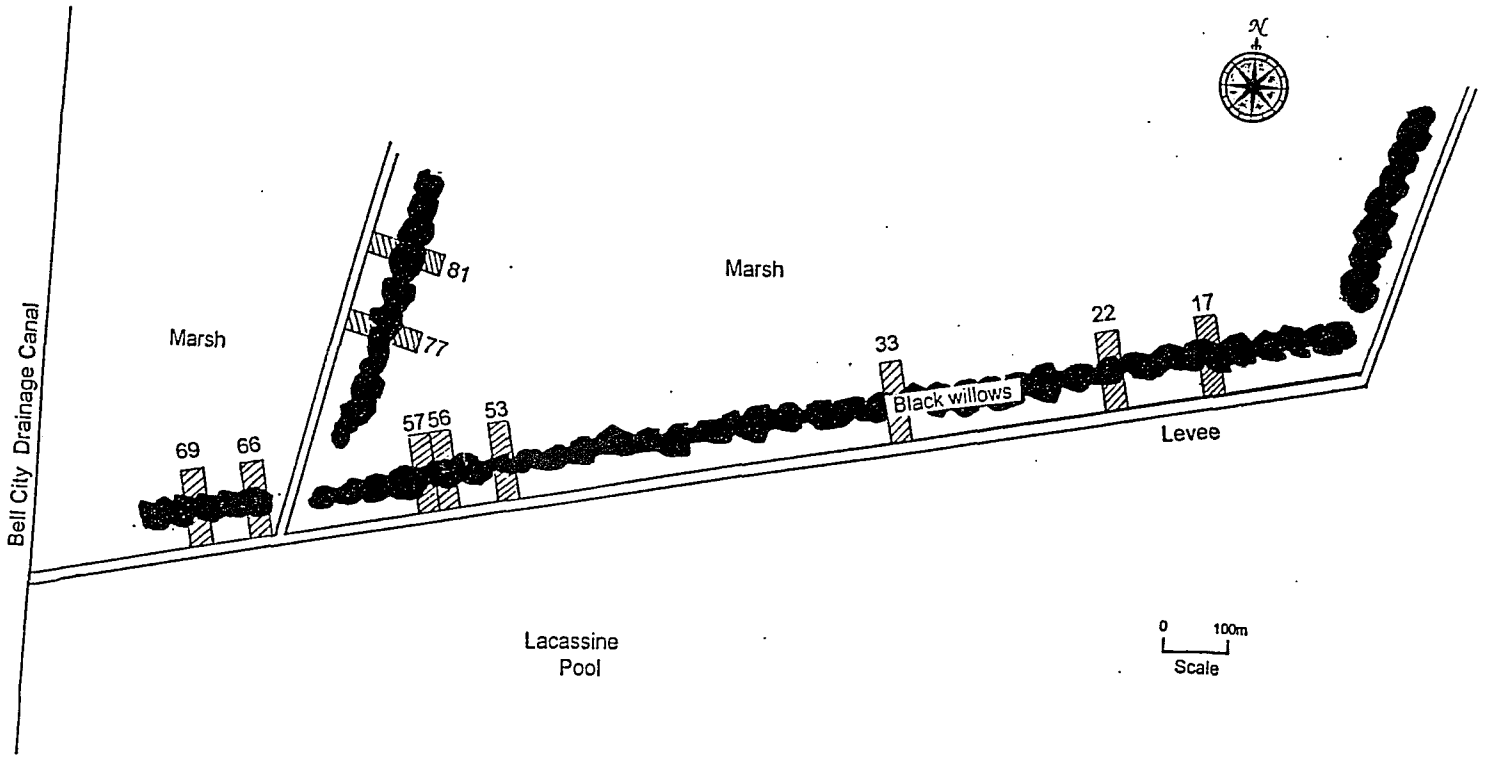


Figure 2.2. Study sections in the black willow site in which abundance of nesting Cattle Egrets was determined, Lacassine National Wildlife Refuge, Louisiana, 1994.

We estimated the number of ibis nests at the buttonbush site by counting every visible nesting adult.

1995

I divided the black willow site into 27 100-m sections and placed numbered stakes along the levee to designate section boundaries (Fig. 2.3). This was done prior to the arrival of any birds to minimize the possibility of inhibiting nesting.

In early March we began monitoring the black willow and buttonbush sites weekly to determine arrival and nest initiation times of ibises and other species. Counts were taken at approximately 7:00 a.m. We observed birds in the buttonbush colony from the bed of a truck parked on the nearby levee. At the black willow site, we collected and recorded data from inside the truck as we drove slowly, or stopped, along the levee. We remained in the truck because birds were more likely to flush when we walked along the levee. I counted White-faced Ibises, and an assistant counted all other species. We used binoculars to observe nests and hand-held counters to tally the numbers of species in each section. Nests were considered active if occupied by an adult or a nestling. Site, section, date, species, number of birds, and number of nests were recorded through 26 July 1995.

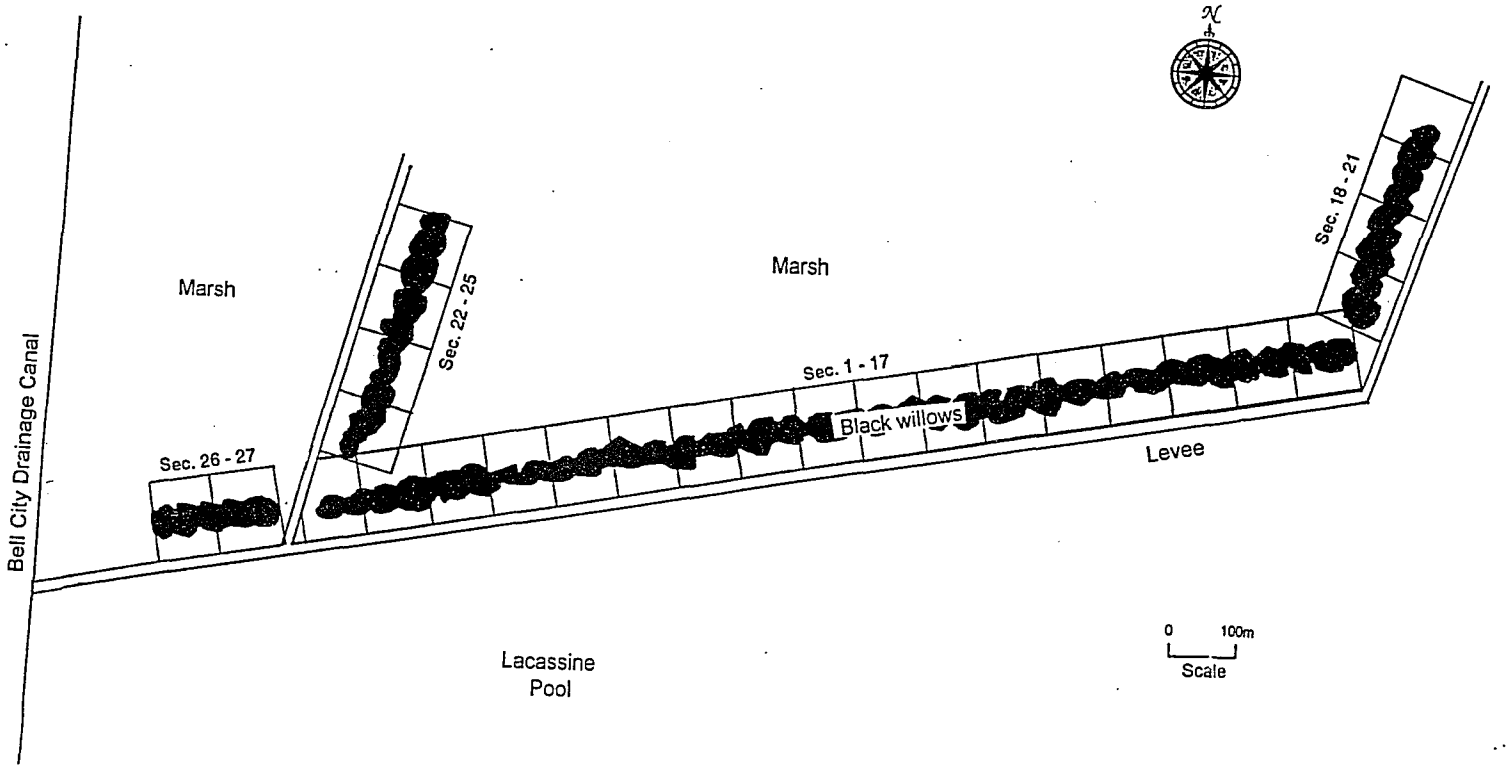


Figure 2.3. Study sections in the black willow site in which abundance and chronology were determined for nesting White-faced Ibises, Lacassine National Wildlife Refuge, Louisiana, 1995.

RESULTS

BLACK WILLOW SITE

In 1994 we counted 1,292 White-faced Ibis nests and 74 nests of other species at peak nesting. We estimated there were 2,322 Cattle Egret nests. Fewer birds nested in 1995; we counted 622 ibis nests, 1,057 egret nests, and 50 nests of other species at peak nesting (Table 2.1). In 1995 we counted each nest as the colony formed.

Yellow-crowned Night-Herons *(Nycticorax violaceus)* were the first to nest at the site (Fig. 2.4). On 14 April we observed seven incubating adults and nine other herons perched nearby. The greatest number of active nests (N = 16) was observed on 18 May. Seven nests were in close proximity, whereas nine others were scattered throughout the site. Nesting was completed by 15 June.

The next species to nest was Cattle Egret. Twenty nests were under construction on 19 April. The greatest number of egrets (1,433) was observed on 6 June, and the largest number of egret nests (1,057) was observed on 21 June (Fig. 2.5). By 26 June, the number of active nests decreased from 1,057 to 946.

Tricolored Herons (*Egretta tricolor*) were first observed on 4 May, when we saw six birds and two active nests. Peak numbers (N = 11 birds) and active nests (N = 5) were observed on 6 June.

Table 2.1. Number of active nests (by date) of White-faced Ibises and Cattle Egrets in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1995.

DATE	WHITE-FACED IBIS	CATTLE EGRET
April		
19		20
26		27
May		
4		109
13		310
18		325
23	1	337
29	8	433
June		
6	213	696
15	531	891
21	622	1057
26	330	946
July		
4	201	931
12	125	510
18	117	476
26	63	422

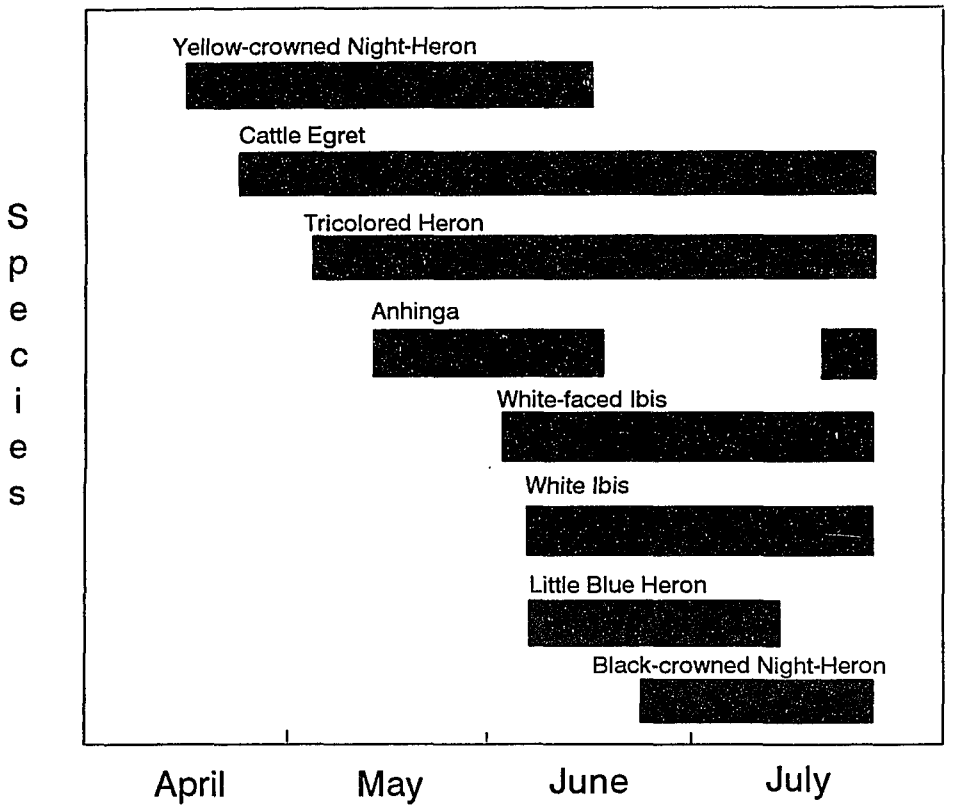


Figure 2.4. Nesting periods of waterbirds at the black willow site, Lacassine National Wildlife Refuge, Louisiana, 1995. All but Yellow-crowned Night-Herons and Little Blue Herons were still active on 26 July.

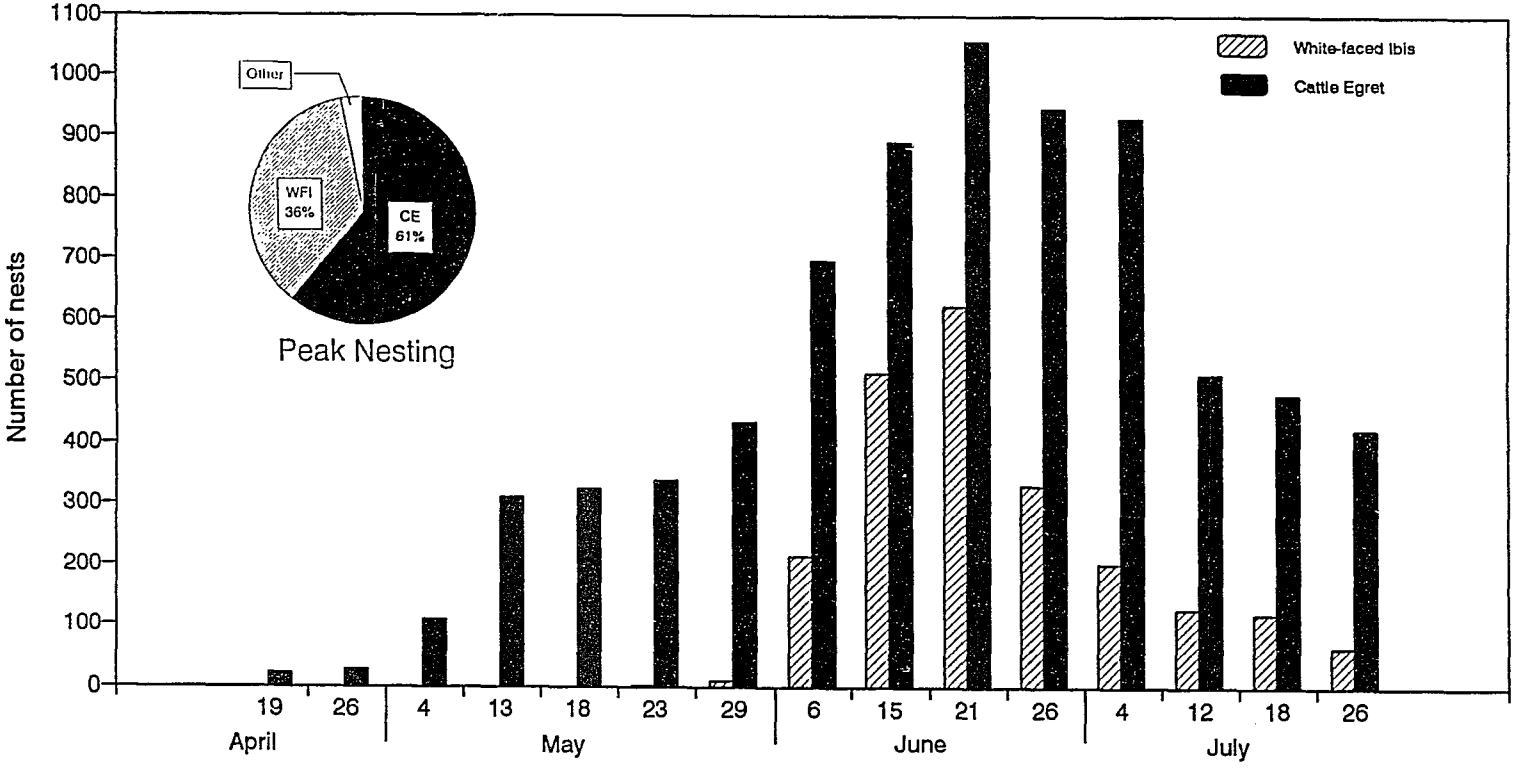


Figure 2.5. Number of active nests (by date) of White-faced Ibises and Cattle Egrets nesting at the black willow site, Lacassine National Wildlife Refuge, Louisiana, 1995. Other nesting species included: White Ibis (20), Yellow-crowned Night-Heron (16), Tricolored Heron (5), Black-crowned Night-Heron (4), Anhinga (4), and Little Blue Heron (1).

Four Anhingas (*Anhinga anhinga*), including one incubating adult, were observed on 13 May. That nest was active through 15 June, but on 18 July we saw three new Anhinga nests.

White-faced Ibises were seen flying over the site between 14 April and 4 May, when they first perched in the black willows. On 23 May we observed 32 ibises, including 6 paired ibises; one pair was building a nest (Figs. 2.4, 2.5, Table 2.1). Six days later there were 76 individuals and eight nests. Ibis numbers had increased dramatically by our next visit on 6 June, when we counted 1,164 adult ibises, the most observed, and 213 active nests. By 15 June, although the number of nests had increased to 531, fewer individual ibises were seen. Presumably, mates were away from the colony foraging for food. The greatest number of active nests was observed on 21 June, but dropped sharply from 622 to 330 in the following 5 days, and continued to decline to 63 by 26 July. Most losses occurred in sections 1 through 12 in the colony (Fig. 2.3).

The first sighting of White Ibises (*Eudocimus albus*) was on 6 June, when we counted 11 individuals and observed four nests being built. These birds tended to nest conspecifically. Peak nesting (N = 20) occurred on 21 June, but numbers gradually declined until 26 July when only one fledgling remained.

One Little Blue Heron (*Egretta caerulea*) nest was observed on 6 June. No young were seen, and it was abandoned by 12 July.

Except for the late-nesting Anhingas, the latest nester was the Black-crowned Night-Heron (*Nycticorax nycticorax*). We observed four nesting on 21 June, but although adults were on nests through 26 July, we never saw young Night-Herons.

Other species perching, but not nesting, at the site included: Snowy Egrets (*Egretta thula*), Olivaceous Cormorants (*Phalacrocorax olivaceus*), Least Bitterns (*Ixobrychus exilis*), and Green Herons (*Butorides striatus*).

BUTTONBUSH SITE

We estimated there were approximately 312 pairs of nesting White-faced Ibises in the buttonbush colony in 1994.

On 14 April 1995, we counted 42 Great Egrets (*Casmerodius albus*) with 23 active nests (the largest number observed) and 17 Little Blue Herons with two active nests in the buttonbush site. Although it was difficult to see eggs or chicks through the dense vegetation, we occasionally viewed as many as three Great Egret chicks per nest when they solicited food from returning adults. Egrets were last observed nesting in the site on 29 May.

Little Blue Heron nesting peaked on 4 May, when nine active nests were counted, and the herons were last seen on 29 May.

White-faced Ibises flew over the site each week after 14 April. They were first observed perching on 18 May, and by 23 May seven ibises and two active nests were seen. The greatest number of nests (N = 16) were observed on 15 June.

We saw one Glossy Ibis (*Plegadis falcinellus*) foraging in water near the buttonbush colony on 18 May. This was the only Glossy Ibis we observed in the refuge in 1994 and 1995.

Fourteen Cattle egrets perched in the site on 15 June, but none nested.

WATER WILLOW

We first observed White-faced Ibis nests in the water willow site on 18 May 1995, when we discovered approximately 125 adults and 50 active nests on two water willow "islands." The few nests with visible contents contained either two or three eggs. Two Yellow-crowned Night-Herons and two Tricolored Herons had nests. On 15 June there were 38 active ibis nests and one large chick approximately 14 days old. Both Tricolored Heron nests and one Yellow-crowned Night-Heron nest were still active. In addition, two Great Blue Heron (*Ardea herodias*) nests were observed. Eleven days later, White-

faced Ibises (four adult and seven young) were the only species remaining.

DISCUSSION

CHRONOLOGY OF SITE SELECTION

The first nesting White-faced Ibises in the refuge was observed on 18 May 1995 in the water willow colony. Nest construction is normally completed in 2 to 4 days, but may require as many as 10 days (Belknap 1957, Kotter 1970, Schreur 1987). Eggs are usually laid every 2 days (Kotter 1970, Capen 1977). By allocating 5 days for nest construction and 5 days for laying three eggs, I estimated that the earliest nests were begun by 8 May 1995. On 23 May we saw two active ibis nests in the buttonbush site. Earlier that day we watched a pair of ibises building the first ibis nest in the black willow colony. The fact that ibises nested in the water willow site about 15 days before the black willow site, and in the buttonbush site a few days earlier than the black willow site, may indicate a preference for those sites over the black willow site. Water willows may have been preferred habitat because of deep water under the nesting vegetation, or because of their isolated location, with less human disturbance and fewer mammalian predators.

NESTING PERIOD

The White-faced Ibis nesting period in my study (beginning on 8 May 1995) conforms with incubation periods

reported for Louisiana (1 April through 15 June) by Martin and Lester (1990). Hatching in the black willow site occurred between 19 June and 16 July, with peak hatching occurring on 6 July. Belknap (1957) witnessed two breeding cycles in Lacassine--one beginning in early to mid-April and the other beginning in late May.

ABUNDANCE

There were more than twice as many White-faced Ibis and Cattle Egret nests in the black willow site in 1994 than in 1995. Estimated peak numbers of White-faced Ibis nests in 1994 and 1995 were 1,292 and 622 respectively. There were approximately 2,322 Cattle Egret nests in 1994 and only 1,057 in 1995. Nests of all other species also declined, from 74 in 1994 to 50 in 1995.

There may be no unusual reason that fewer ibises nested at the site in 1995 than in 1994. The numbers may simply reflect the normal fluctuating breeding patterns of White-faced Ibises which are known to be highly nomadic (Ryder 1967, Steel 1984, Ivey *et al.* 1988, Henny and Herron 1989). However, King reported that White-faced Ibises seem to "shift" between coastal breeding sites in Texas and Louisiana as a result of changing environments (King *et al.* 1980). The low water levels in the black willow site in 1995 may have caused some ibises to move to other nesting areas in Texas or Louisiana.

A dramatic decline in active ibis nests occurred in 1995. Between 21 June and 26 July, the number of nests dropped from 622 to 63. Allowing 21 days for incubation and 28 days for chicks to fledge (Ehrlich *et al.* 1988), the earliest ibis nests should have been active until 25 July, but most were not. The acute loss of ibis nests was not a natural result of chicks fledging and leaving the colony; as discussed in Chapter III, predation seems to have been responsible for most nest losses.

ASSOCIATED WATERBIRDS

At peak nesting, Cattle Egrets made up 61% of all nesting birds compared with 36% for White-faced Ibises. Cattle Egret numbers have increased as the birds have extended their range throughout the United States (Crosby 1972). Their presence in the United States was first observed in 1941 in Florida, where in 1953 their first nests were also discovered. Currently they occur in 42 of the 48 contiguous states (Line 1995). Researchers have come to conflicting conclusions about whether their rapid expansion has been detrimental to birds in existing heronries who are compelled to compete for similar food, nesting sites, and nesting materials. Competition was prevented in most cases because of differences in food items (Jenni 1969, 1973) or nesting periods. In southern states, Cattle Egrets nested later than native species (Dusi and Dusi 1968, Jenni 1969, Weber 1972). In New

Jersey, where Burger (1978) found Cattle Egrets arriving simultaneously with native herons and egrets, there may have been some competition.

At the black willow site, however, Cattle Egrets nested earlier than six of the seven other species, and 5 weeks before White-faced Ibises (Figures 2.4, 2.5). Only Yellow-crowned Night-Herons arrived earlier; consequently Cattle Egrets had nearly first choice of nesting sites and materials. There were 337 active egret nests when White-faced Ibises began forming breeding pairs, and Cattle Egret chicks were hatching while ibises were still breeding. At their peak, egret nests (1,057) outnumbered ibis nests (622) almost two to one. Egrets feed entirely on insects and so are not dependent upon aquatic habitats. The White-faced Ibis, however, has more limited nesting habitat requirements.

Although egret nests are smaller than ibis nests, it appeared that egret nest-sites and materials were similar to those of ibises. Consequently, large numbers of nesting egrets could have a deleterious effect on reproductive rates of nesting ibises if sites are limited, and egret use of the black willow site may be especially detrimental to breeding ibises in Louisiana, where numbers seem to be declining.

The egrets' impact on ibises nesting in the black willow colony may depend on environmental conditions each

year. In 1994, for example, most of the colony-site was underwater, and the presence of egrets probably had a negative impact on ibises. Nest-sites were so occupied in the black willow colony-site that late-nesting egrets nested in trees adjacent to the colony. Their extensive use of nest-sites and materials may have prevented some ibises from nesting altogether or caused them to use inferior sites.

In 1995, however, when nests were over dry land, the presence of egrets may have benefited ibises. Cattle Egrets (composing 61% of the nesting birds) suffered egg and chick predation along with ibises. Without them, it is possible that no ibis eggs or hatchlings would have survived. The existence of large numbers of eggs and chicks available to predators may have enabled some ibis young to survive.

Another nesting species that may have been detrimental to ibis reproduction was the Black-crowned Night-Heron, a predator of young nestlings (Frederick and Collopy 1989, Bildstein 1993). Black-crowned Night-Herons did not begin nesting until 21 June, shortly after Cattle Egret chicks hatched and 5 days before ibis chicks began hatching. Martin and Lester (1990) sampled wading bird colonies in Louisiana and found this herons' normal incubation period was 16 March to 16 June. Perhaps they nest later to benefit from a ready food supply.

LITERATURE CITED

Belknap, H.W. 1957. Observations on the White-faced Ibis (*Plegadis chihi*) in Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge, LA.

Bildstein, K.L. 1993. White Ibis: wetland wanderer. Smithsonian Institution Press, Washington, D.C.

Burger, J. 1978. Competition between Cattle Egrets and native North American herons, egrets, and ibises. Condor 80:15-23.

Capen, D.E. 1977. The impact of pesticides on the White-faced Ibis. Ph.D. Dissertation, Utah State University, Logan, Utah.

Crosby, G.T. 1972. Spread of the Cattle Egret in the Western Hemisphere. Birdbanding 43:205-212.

Dusi, J.L., and R.T. Dusi. 1968. Ecological factors contributing to nesting failure in a heron colony. Wilson Bull. 80:458-466.

Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. The birder's handbook: a field guide to the natural history of North American birds. Simon and Schuster, Inc., New York, NY. 785 pp.

Frederick, P.C., and M.W. Collopy. 1989. The role of predation in determining reproductive success of colonially-nesting wading birds (Ciconiiformes) in the Florida Everglades. Condor 91:860-867.

Henny, C.J., and G.B. Herron. 1989. DDE, selenium, mercury, and White-faced Ibis reproduction at Carson Lake, Nevada. J. Wildl. Manage. 53:1032-1045.

Ivey, G.L., M.A. Stern, and C.G. Carey. 1988. An increasing White-faced Ibis population in Oregon. W. Birds 19:105-108.

Jenni, D.A. 1969. A study of the ecology of four species of herons during the breeding season at Lake Alice, Alachua County, Florida. Eco. Monogr. 39:245-270.

Jenni, D.A. 1973. Regional variation in the food of nestling Cattle Egrets. Auk 90:821-826.

King, K.A., D.L. Meeker, and D.M. Swineford. 1980. White-faced Ibis populations and pollutants in Texas, 1969-1976. Southwest Nat. 25:225-239.

Kotter, B.L. 1970. An ecological natural history of the White-faced Ibis (*Plegadis chihi*) in northern Utah. M.S. Thesis, University of Utah, Salt Lake City.

Line, L. 1995. African Egrets? Holy Cow! International Wildlife. 25(6):45-55.

Martin, R.P., and G.D. Lester. 1990. Atlas and Census of wading bird and seabird nesting colonies in Louisiana: 1990. Louisiana Department of Wildlife and Fisheries, and Louisiana Natural Heritage Program. Special Report No. 3. 182 pp.

Portnoy, J.W. 1977. Nesting colonies of seabirds and wading birds in coastal Louisiana, Mississippi, and Alabama. U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-77/07. Washington, D.C. 126 pp.

Ryder, R.A. 1967. Distribution, migration and mortality of the White-faced Ibis (*Plegadis chihi*) in North America. Birdbanding 38:257-277.

Ryder, R.A., and D.E. Manry, 1994. White-faced Ibis (*Plegadis chihi*). In The Birds of North America, No. 130 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Schreur, J.L. 1987. Ciconiiform reproductive success and public viewing in the San Luis Valley, Colorado. M.S. Thesis, Colorado State University, Fort Collins.

Steele, B.B. 1984. Effects of pesticides on reproductive success of White-faced Ibis in Utah, 1979. Colonial Waterbirds 7:80-87.

Tiner, R.W. 1993. Field guide to coastal wetland plants of the southeastern United States. The University of Massachusetts Press, Amherst, MA.

Weber, W.J. 1972. A new world for the Cattle Egret. Nat. Hist. 82:56-63.

CHAPTER III

NEST-SITE SELECTION AND REPRODUCTIVE SUCCESS OF THE WHITE-FACED IBIS IN LACASSINE NATIONAL WILDLIFE REFUGE, SOUTHWESTERN LOUISIANA

INTRODUCTION

Reproductive success of birds is influenced by several factors, one of which, nest-site selection, is especially critical to nestling survival (Martin 1988). Nests serve several functions. In addition to providing shelter for eggs, young chicks, and roosting adults, the purpose of nests is protection from predators (Gill 1990). Predation is usually the greatest cause of reproductive failure, and nest location determines its susceptibility to predators (Lack 1954, Ricklefs 1969, Milstein *et al.* 1970, Frederick and Collopy 1989).

The purpose of my study was not only to assess nesting success of the White-faced Ibis (*Plegadis chihi*) by the normal measures (clutch size, hatching rate, hatching success, nest success, and fledging success) but to examine nest-site parameters (substrate, height, proximity to edge, water status, nearest-neighbor species, and nearest-neighbor distance) to discover the extent to which these parameters influence reproductive success.

The specific objectives of this part of my study were to determine: (1) average reproductive success;

(2) reproductive success as a function of nest location; (3) annual reproductive success; and (4) causes of mortality, including identification of predator species and their effects on reproductive success.

METHODS

GENERAL

This study was conducted during two nesting seasons of the White-faced Ibis in Lacassine National Wildlife Refuge (LNWR) in southwestern Louisiana (Fig. 3.1). Data were collected in June and July of each year from 292 nests: 50 nests in 1994 and 242 nests in 1995.

STUDY SITE

In early June 1994, I divided the black willow (*Salix nigra*) site into 90 sections of 30 m. A total of 50 nests, with eggs only, was selected from four randomly chosen sections (22, 33, 66, 69) (Fig. 3.2), and each nest was marked with numbered surveyor's flagging tape.

In 1995 I expanded the size of the sections to 100 m for a total of 27 sections (Fig. 3.3) to increase the sample size and to minimize investigator disturbance by decreasing the number of entries into the colony. In early March 1995, before birds began arriving at the site, we marked trees at the boundaries of three randomly selected sections (5, 7, and 8) with flagging tape and placed corresponding numbered stakes on the levee.

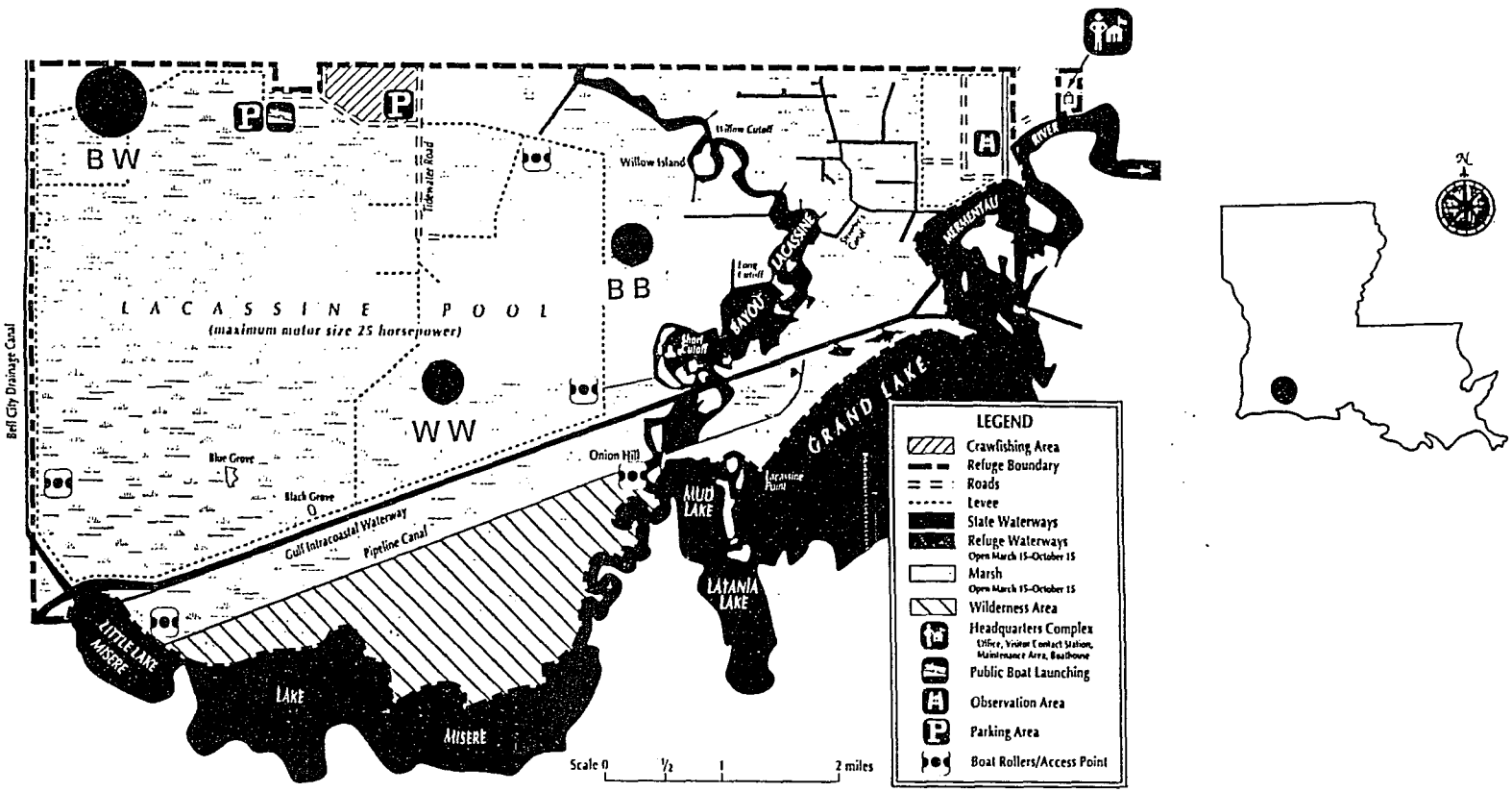


Figure 3.1. Major nesting sites of White-faced Ibises in Lacassine National Wildlife Refuge, Louisiana, 1995 (BW = black willow colony; BB = buttonbush colony; WW = water willow colony).

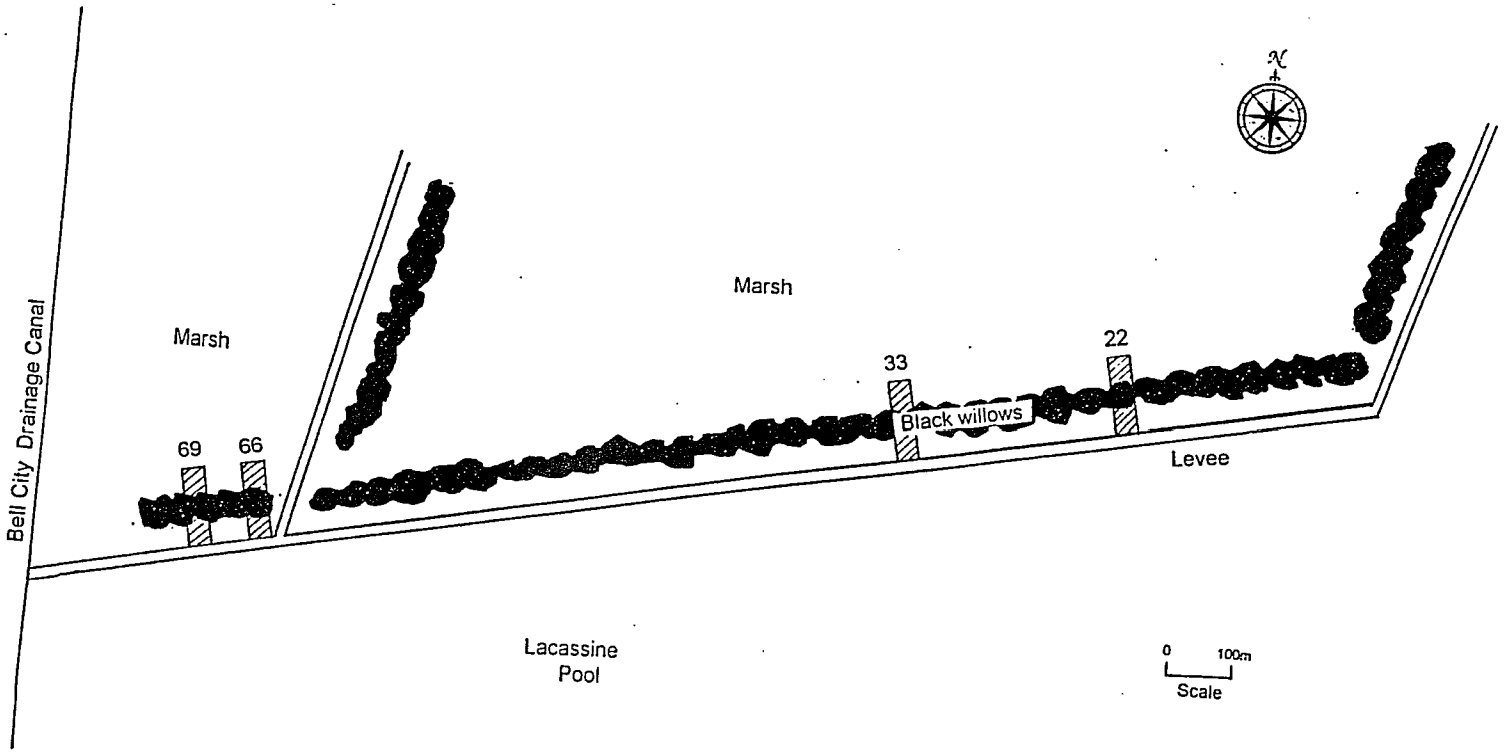


Figure 3.2. Study sections in the black willow site, Lacassine National Wildlife Refuge, Louisiana, 1994.

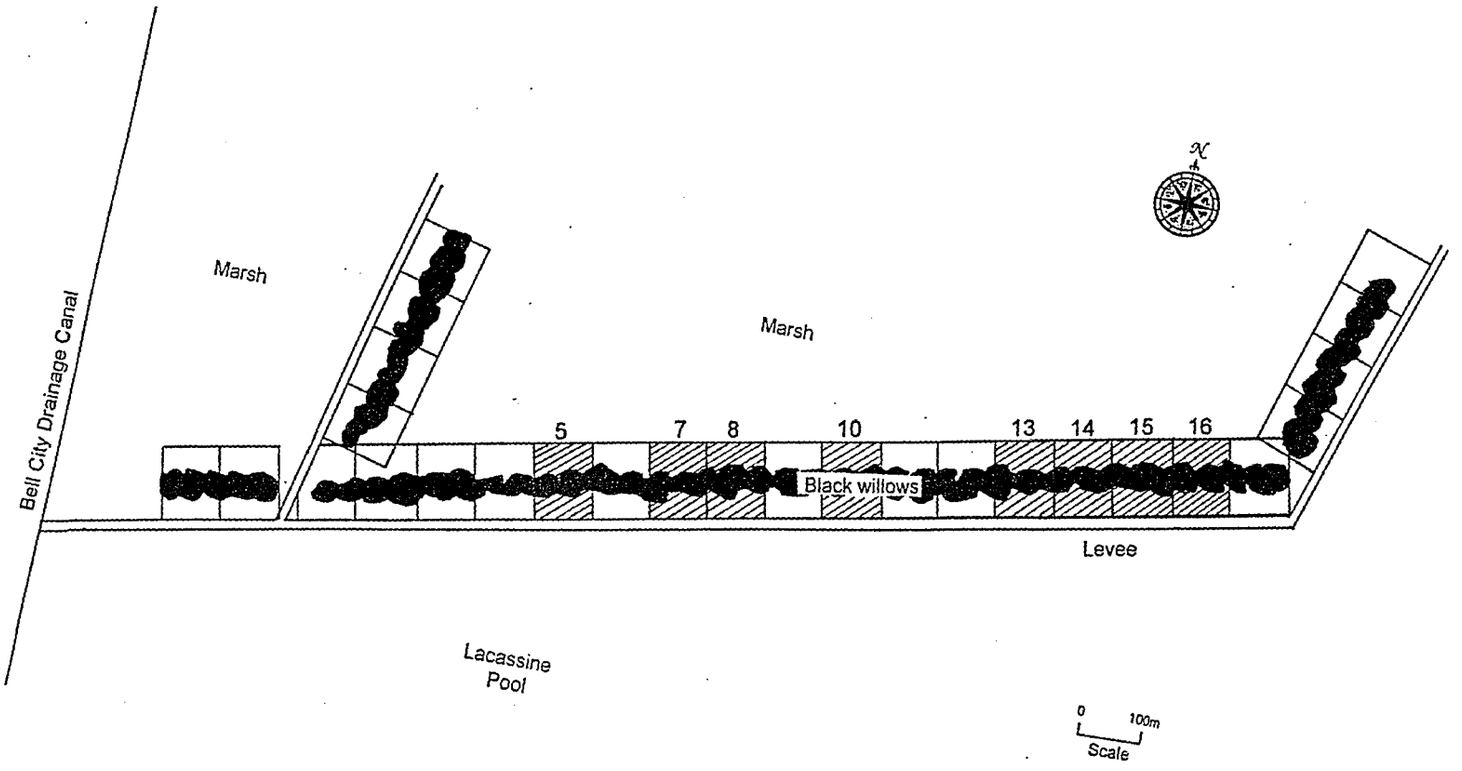


Figure 3.3. Study sections in the black willow site, Lacassine National Wildlife Refuge, Louisiana, 1995.

To determine the effects (if any) of investigator disturbance, I chose section 10 to serve as a control section with reduced investigator contact (Fig. 3.3). This section had vegetation, water levels, and exposure to sun and wind similar to that in the experimental sections.

We continued to observe the colony from the levee every week to monitor nesting progress. To minimize our impact, we waited until late in the incubation stage (21 days) before entering the colony and marking nests. We selected 124 nests that contained eggs only and tied orange surveyor's flagging tape around tree trunks or the nearest limb under each nest. Ibis nests were identified by egg size and color.

Upon our next entry 5 days later, we discovered that all eggs in 89 nests had been depredated for a loss of 227 of the 324 known eggs (70%). Nest losses continued and were so extensive (97%) that only four active nests remained 1 week later. Similarly, although we had not entered the section, we saw that only 1 of 30 nests in the control section was still active. Unable to continue our study in those sections, I improvised by selecting 118 nests (with eggs and chicks) in the few remaining sections (13 through 16) containing active nests. These new nests were marked and numbered consecutively with flagging tape. We continued monitoring the original sections from the levee for signs of renesting.

FIELD PROCEDURES

To minimize disturbance to the colony, we wore similar clothes each day and worked as quickly and quietly as possible. Usually, I alone observed nest status and handled nestlings while an assistant recorded data, moved ladders and boats, and monitored the movements of nearby alligators (*Alligator mississippiensis*). When necessary, I used a crab net to capture large chicks. We arrived at the colony at approximately 7:00 a.m. and departed around noon to prevent undue heat exposure to the eggs and chicks, and we did not enter the colony during rainy weather.

Visits to the colony were made on alternate days. We drove a truck on the levee to each study section and used a 4-m pirogue to cross the deep water separating the levee and the colony. We used a larger, sturdier "push-pole" boat when large alligators that were about as long as our pirogue were present in our study sections. Our pattern was to enter the west boundary of each section, proceed through the colony, and exit at the eastern end.

In 1994 we were able to reach approximately 85% of all nests in the experimental sections by climbing trees or using a 3-m ladder. We marked nestlings' toenails with different-colored nail polish according to hatching order. When they were larger, we banded them with numbered

plastic bands that we removed shortly before the birds became inaccessible.

In 1995 we mounted a mirror on a 2.4-m pole (which could be extended an additional 2.4 m) to see the contents of nests too high or extending too far over the deep water for us to reach. We were able to observe the contents of approximately 95% of the nests within the study sections. Instead of using nail polish and numbered bands, we used expandable plastic bird bands (size 4) of different colors to distinguish chicks and to identify hatching sequence. These bands were also eventually removed.

We measured the outside diameter of nests, and the lengths and widths of all eggs in eight randomly selected nests.

In both years, upon discovery of each nest, we recorded various nest characteristics (Table 3.1). On subsequent visits we recorded the status of each nest and its contents: eggs (number, pipping stage, broken, missing, etc.) and chicks (number, injuries, missing, dead, etc.). When hatching order was known, the first chick hatched in each nest was designated an "A" chick, the second designated "B", etc. We also recorded weather conditions and other relevant observations, such as signs of predators (tracks, feces, feathers, etc.) as well as any direct sightings of predators.

Table 3.1. Information collected for each White-faced Ibis nest sampled in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994 and 1995.

1994 and 1995

(1) Date nest discovered

(2) Section number

(3) Nest number

(4) Nest substrate

(5) Nest height

(6) Water status (over water or over land)

(7)* Nest status (no. of eggs/chicks)

1995 only

(8) Location (edge or interior)

(9) Nearest-neighbor species

(10) Nearest-neighbor distance

* Updated during each visit

We continued searching for new nests to determine if renesting occurred.

We monitored chicks until they disappeared, died, or fledged. I considered chicks fledged at 14 days because at that age they began leaving their nests and became indistinguishable from other congregating chicks.

For the purposes of this research, I defined applicable terms and compiled them in Table 3.2.

DATA ANALYSIS

Statistical analysis

Statistical analyses were performed with the Statistical Analysis System (SAS) available at Louisiana State University's Computing Services Center (SAS Institute, Inc. 1990). I used SAS to test for differences in mean clutch size, brood size, and fledging success per nest by year. I also tested for differences due to the following nest-site parameters: (1) substrate; (2) height; (3) proximity to edge; (4) water status; (5) nearest-neighbor species; and (6) nearest neighbor's distance.

I used analyses of variance (ANOVA) models and Student *t*-tests when there were two classification levels. When there were more than two classification levels (parameters 1, 2, and 5 above), I used ANOVA and Fisher's protected least squares difference (LSD) to determine specific differences. The level of significance for ANOVA was Alpha = 0.05.

Table 3.2. Glossary of terms used for the purposes of this study of the White-faced Ibis, Lacassine National Wildlife Refuge, Louisiana, 1994 and 1995.

REPRODUCTIVE PARAMETERS:

GENERAL

(1) **Missing:** Nest, egg, or chick disappeared. Although "missing" contents were most likely a result of predation, I made a distinction between "missing" and "depredated" to help determine predator types.

(2) **Depredated:** Direct evidence of predatory behavior: broken or punctured eggs with contents at least partially eaten, or eggshells in or under the nest; dead chick in nest, or if a chick was missing but an injured sibling was found in nest

(3) **Collapsed:** Nest fully or partially collapsed

(4) **Abandoned:** Entire clutch of eggs was cold and (usually) covered with debris

NESTS

(1) **Productive:** At least one chick hatched

(2) **Successful:** At least one chick fledged

(3) **Nest productivity:** Percentage of nests in which one or more eggs hatched

EGGS

(1) **Hatching rate:** Percentage of fertile eggs (those present at hatching time that produced a chick)

(2) **Hatching success:** Percentage of original eggs that hatched

CHICKS

(1) **Fledged:** Chick survived at least 14 days

(2) **Fledging success:** Percentage of nests in which one or more chicks survived at least 14 days

(3) **Hatch day:** Day chick hatched (day 0)

(4) **A-chick:** First chick hatched in each nest. Second hatched a B-chick, etc.

(5) **Death unknown:** Dead chick with no apparent injury

(6) **Date missing or found dead:** Arbitrarily assumed to be midway between the last two visits (Mayfield 1961, 1975).

NEST-SITE PARAMETERS:

(1) **Substrate:** Taxon of vegetation that supports nest

(2) **Height:** Distance from ground or water surface to bottom of nest. Nest heights were divided into three uniform categories:

Lower: (0.10-1.8 m)

Middle: (1.81-3.6 m)

Top: (3.61-5.4 m)

(3) **Edge:** Nest location within 1.8 m of the perimeter of the colony-site (vs. interior)

(4) **Over-water nests:** Trunks of nest-trees in water (vs. over-land nests)

(5) **Nearest-neighbor species:** Closest nesting species to an ibis nest

(6) **Nearest-neighbor distance:** Distance between ibis nest and nearest nesting neighbor

I used contingency tables from Chi-square tests for homogeneity to analyze differences in substrate, height, proximity to edge, and nearest-neighbor species between nests in sections 5 through 8 and sections 13 through 16. The level of significance was Alpha = 0.05.

Nest success

In 1994 when nests were selected they were in various stages of incubation. Therefore, I used Mayfield's method to estimate the overall probability of nest success because his method provides for the fact that nests are discovered at different stages in the nesting cycle (Mayfield 1961, 1975). Following this method, I determined total nest "exposure"--the number of nests in the sample and the amount of time each nest was under observation.

Because the hazards to nests varied during the incubation and nestling stages, I calculated average daily mortality and survival rates separately for both stages. The probability of nest success during each stage was the exponential of the daily survival rates: 21 days during the incubation stage and 14 days during the nestling stage. I multiplied these exponential rates by the hatching rate to estimate the overall probability of nest success.

I calculated "nest-day" exposure for the incubation stage, but "nest-day" and "nestling-day" exposure for the

nestling stage because some chicks continued to survive in nests in which one or more chicks were lost. Mayfield (1975) recommends using his method only if "losses do not bunch up early or late in any stage." Therefore, because of the massive losses that occurred throughout the colony within a few days in 1995, I was unable to apply this method to nests in 1995.

Annual reproductive success

Each year we counted the actual number of active nests and extrapolated the mean number of hatchlings and fledglings per nest from the study sections to the entire colony to estimate annual reproductive success. In 1994 data were extrapolated from four randomly selected sections representing 4% of the colony. In 1995 results were extrapolated from seven sections representative of 32% of the colony. The three depredated sections (5, 7, and 8) contributed 64% to the total estimate because they represented approximately 64% of the colony, and results in the four subsequently chosen sections (13 through 16) contributed 36% because they were typical of approximately 36% of the colony.

Presentation of results

I first present average results for general reproductive parameters followed by results as a function of nest location.

Results from 1995 are separated into two distinct categories; 1995A consists of the first 124 nests from randomly chosen sections (5, 7, and 8); these were depredated shortly after selection. 1995B includes 118 nests that were subsequently chosen in sections 13 through 16. I separated the data to avoid mixing results from nests selected by different methods. Results from 1995A nests represent the outcome of approximately 64% (14 of the 22 active sections where nesting occurred) of the nests in the colony. They are presented in Tables 3.3, 3.4, and 3.6. Data from 1995B rather than 1995A are used throughout my results section, graphic presentations, and in the discussion unless otherwise stated. It is important to note that 1995B results reflect the fates of nests in only eight sections (34%) of the site.

RESULTS

NESTS - GENERAL

Nests in the black willow colony were constructed primarily of sticks and small twigs, and were lined with herbaceous vegetation from the surrounding area. The foundation of many nests contained large sticks, some measuring as much as 2.5 cm in diameter and up to 1 m long. The average outside diameter of eight nests measured 42.7 cm. I found no foreign or human-manufactured materials in any nests. As observed in other studies (Belknap 1957, Kotter 1970, Alford 1978), ibises

intermittently reinforced their nests by adding sticks to the nests during the incubation stage and for about 2 weeks during the brooding stage. Nests abandoned during the incubation stage usually disappeared within 48 hours, most likely as a result of pilfering by other nesters. I observed an adult ibis repeatedly take sticks from a nearby vacant nest. It "hovered" remarkably well while it plucked a stick from the nest, before returning to add it to its own nest. I timed this activity and found that the ibis added about one stick every two minutes to its nest.

Adults removed eggshells from their nests shortly after hatching but did not remove dead chicks throughout the nesting period.

I did not observe any obvious attempts at renesting in either year, nor did chronology data taken in 1995 provide conclusive evidence of renesting (Chapter II). In a few nests, however, clutches were laid much later than those in other nests; so much later that some chicks had already hatched in other nests. These occurrences in four nests in 1994 and one nest in 1995 may have been indications of renesting attempts. The late eggs in 1994 would have hatched about 3 to 4 days after the last chicks in my study nests hatched (14 July), and in 1995 the two late eggs would have hatched 11 days after the last chick hatched (16 July). None of these attempts was successful.

EGG MEASUREMENTS

The average length of 18 eggs found in eight clutches was 50.9 mm with a range of 48 to 52 mm. The average width was 36.2 mm with a range of 34 to 39 mm.

CLUTCH SIZE

1994

In 1994 clutch sizes ranged from one to six eggs with 2.8 ± 0.11 eggs (mean ± 1 SE) (Table 3.3). Clutch sizes of the 14 successful nests (those with fledged chicks) (3.14 ± 0.29 eggs) did not differ significantly from the 36 unsuccessful nests (2.67 ± 0.11 eggs). Because egg losses occurred after these nests were discovered, it is likely that some eggs were lost prior to discovery, and, therefore, clutch sizes were slightly underestimated. The most frequent clutch sizes were three (N = 30) and two (N = 13). Two clutches had one egg, four had four eggs, and one had six eggs (the largest found in either year).

1995

The mean clutch size of 1995A nests (N = 124) was 2.6 ± 0.07 eggs. The mean clutch size of 1995B nests (N = 118) was 2.31 ± 0.07 eggs, but this represents the minimum number of eggs laid: in 77 nests in which chicks had already hatched I allocated one egg per chick (e.g., a nest with one chick and one egg was allocated two eggs). I did not allow for eggs lost or depredated before the nests were found.

Table 3.3. Nesting parameters of White-faced Ibis chicks in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994 and 1995.

	1994	1995A[1]	1995B[2]
Total no. of nests	50	124	118
No. of eggs	140	324	273
Mean no. of eggs	2.8	2.6	2.3
Mean no. of eggs hatched	1.1	0.03	1.7
No. of productive nests (produced at least 1 chick)	22	4	98
No. of eggs	67	11	229
Mean no. of eggs	3	2.8	2.3
Mean no. of eggs hatched	2.6	1.0	2.1
Total no. of chicks	57	4	201
No. of successful nests (produced at least 1 fledged chick)	14	1	49
No. of fledged chicks	19	1	75
Percent of fledged chicks	0.33	0.25	0.37
Mean no. of fledged chicks	1.4	1.0	1.5
Mean no. of fledged chicks/ productive nests	0.9	0.3	0.8
Mean no. of fledged chicks/ all nests	0.38	0.01	0.64
		0.24[3]	

[1] Original nests lost as a result of predation in sections 5, 7, and 8 (represent approximately 64% of the colony)

[2] Nests in sections 13 through 16 (represent approximately 36% of the colony)

[3] 1995A and 1995B combined

Two-egg clutches (N = 52) were the most common clutch size. Forty-two clutches contained three eggs, 18 had one, and 6 had four eggs.

We discovered one nest that contained one White-faced Ibis egg and two Cattle Egret (*Bubulcus ibis*) eggs. All three eggs were missing on our next visit.

HATCHING RATE

The percentage of fertile eggs (those present at hatching time that produced a live chick) was 90% in 1994 and 93% in 1995.

HATCHING SUCCESS

1994

Hatching success (percentage of original eggs that hatched) was 41% in 1994, when 57 chicks hatched from 140 eggs (Table 3.3). The 57 nestlings included 22 A-chicks, 20 B-chicks, 13 C-chicks, one D-chick, and one E-chick.

1995

In 1995, 201 chicks hatched from 273 eggs (74%), but again this is a maximum percentage, because I did not allow for eggs lost prior to marking nests.

Based on the 34 nests with eggs only (in which I could determine hatching order), there were 35 nestlings: 19 A-chicks, 14 B-chicks, and two C-chicks.

EGG MORTALITY

1994

In 1994, 83 of 140 eggs failed to hatch (59%) (Fig. 3.4). Of those that failed to hatch, 45 (54%) were missing and 9 (11%) were depredated (7 by alligators and 2 by fire ants [*Solenopsis* spp.] that entered the egg through the pipped hole). Seventeen eggs (20%) were lost from eight nests that collapsed, eight eggs (10%) were lost from four abandoned nests, and four eggs were infertile (5%). No partial eggs or egg remnants were found in any nests.

1995

In 1995, 72 of 273 eggs (26%) did not hatch. Most unsuccessful eggs were missing (N = 47 eggs, 65%) or depredated (N = 17, 24%). Two eggs were lost from collapsed nests (3%), three eggs (4%) were lost from two nests that appeared to have been abandoned, and three eggs (4%) were infertile. Unlike in 1994, eggshells were observed in and under nests. No whole eggs remained in nests where eggshells were found.

NEST PRODUCTIVITY

1994

The nest productivity rate (percentage of nests in which one or more eggs hatched) was 44%. Twenty-two of 50 nests produced at least one chick, for a mean number of 1.14 $\pm$ 0.20 chicks and a range of zero to five chicks per

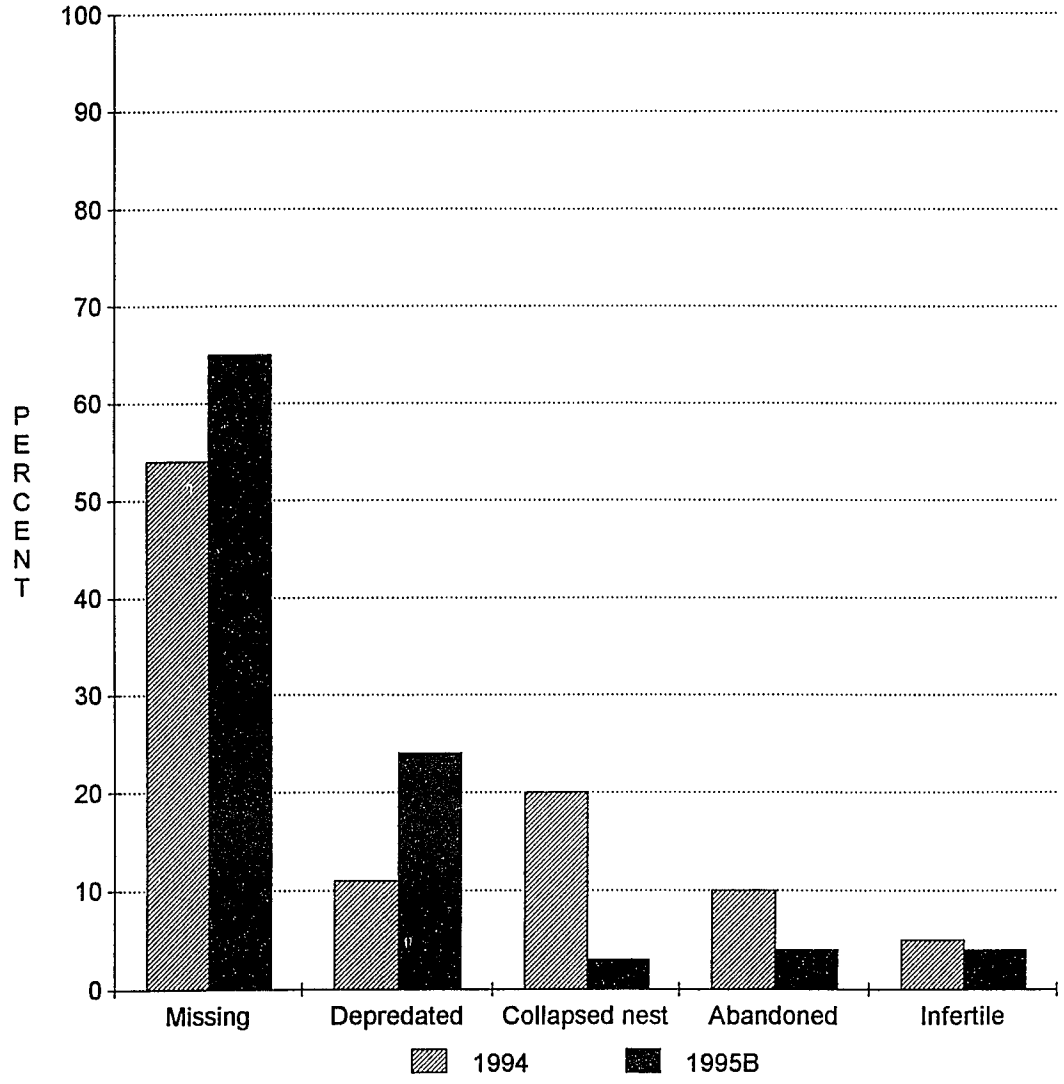


Figure 3.4. Fate of unsuccessful White-faced Ibis eggs in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994 (N = 140) and 1995B (N = 273).

nest (Table 3.3). The most productive clutch size was three. Clutches with three eggs accounted for 59% of all productive nests and 36 (63%) of the nestlings. Nine chicks (16%) hatched from three nests with four eggs each, six (11%) from three nests with two eggs each, one from a nest with one egg, and five (9%) from a nest with six eggs, the largest brood in either year.

1995

At least one chick hatched in 98 nests (83%). The mean number of chicks per nest was 1.70 ± 0.09, and the range was zero to four chicks per nest. The percentage of productive nests and the mean number of chicks per nest are probably overstated because chicks had already hatched in 77 nests by the time nests were discovered, and I did not allow for nests lost earlier. As in 1994, most chicks (45%) were from three-egg clutches.

FLEDGING SUCCESS

1994

Nineteen chicks (33%) survived at least 14 days for a mean of 0.38 ± 0.09 fledglings per nest (Table 3.3).

Five nests had two fledglings. Brood sizes of these nests were two (N = 1 nest), three (N = 3), and five (N = 1). Nine nests had one fledgling; brood sizes were one (N = 1 nest), two (N = 3), and three (N = 5).

Twelve fledglings (63%) were from nests with three eggs. The other seven fledglings were from five nests

with clutch sizes of one, two, four (N = 2 nests), and six.

Survival was affected by hatching asynchrony; 14 of 22 A-chicks (64%), 3 of 20 B-chicks (15%), and 2 of 13 C-chicks (15%) fledged (Fig. 3.5). Neither the D- nor E-chicks fledged, and the B- and C-chicks fledged only in nests in which the A-chick also fledged. The two surviving C-chicks fledged along with A-chicks in nests where the B-chick did not survive.

The fledglings comprised 14 A-chicks (74%), three B-chicks (16%), and two C-chicks (11%) (Fig 3.5).

1995

Of 201 chicks, 75 survived at least 14 days (37%). The mean of 0.64 $\pm$ 0.76 fledglings per nest does not reflect nests lost before I marked nests.

As in 1994, no nest had more than two fledglings, but two chicks fledged in each of 26 nests: those with brood sizes of two (15), three (10), and four (1). One chick fledged in each of 23 nests; brood sizes were one (7), two (8), three (7), and four (1). Most fledglings (51%) were from nests with clutch sizes of two.

Again, fledging was affected by hatching asynchrony; of the 35 nestlings with known hatching sequence, 5 fledged. They were all A-chicks (Fig. 3.5).

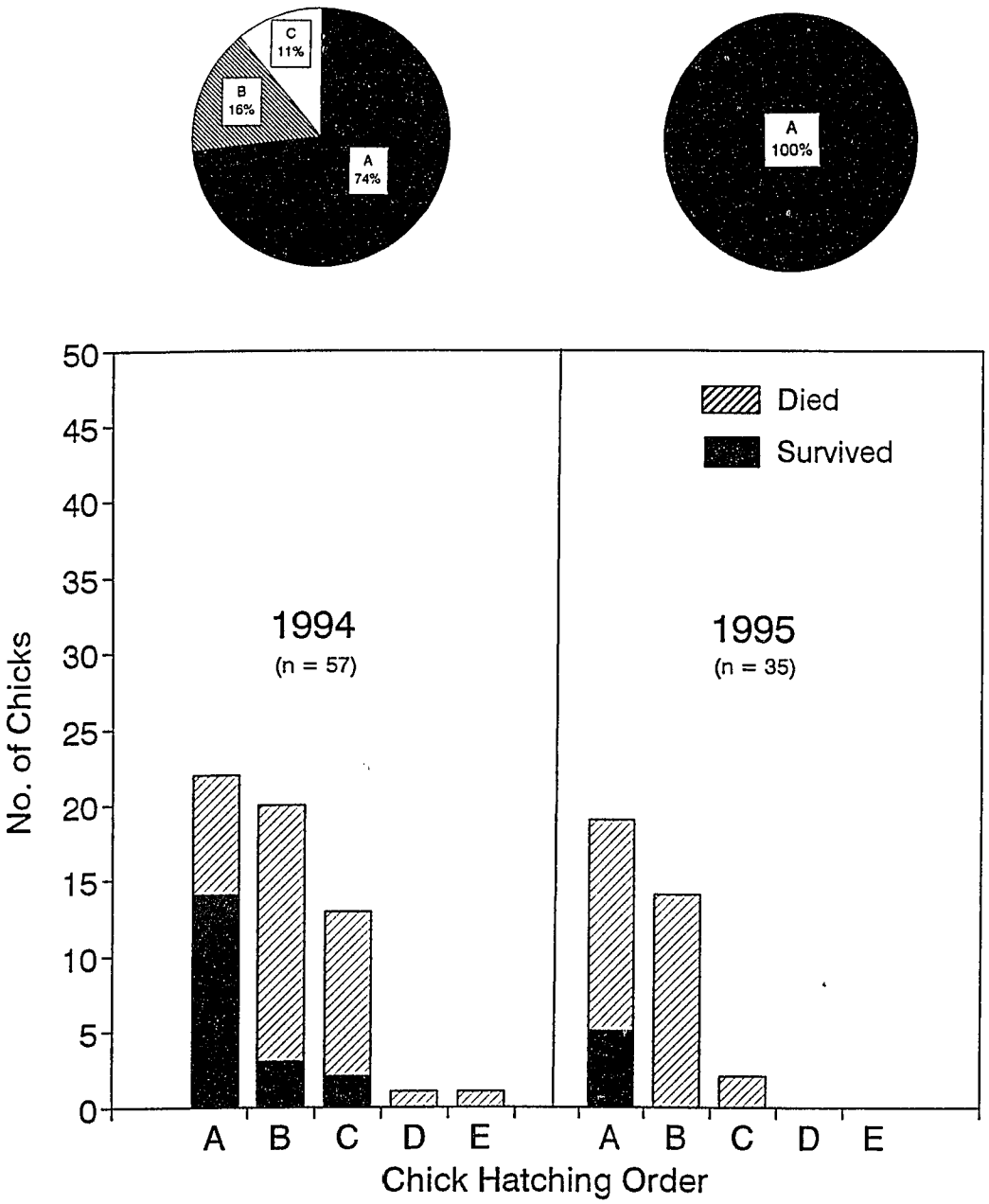


Figure 3.5. Number of fledging White-faced Ibis chicks (by hatching order) in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994 and 1995. Pie charts denote percentages of total surviving young made up by each hatching order group.

CHICK MORTALITY

1994

Thirty-eight of 57 chicks (67%) did not survive 14 days. Most nestling mortality occurred during the 2nd and 3rd days after hatching (32%), and more than half was incurred within 5 days of hatching (56%) (Fig. 3.6). Lowest mortality occurred on days 10 and 11 (5%). Cumulative losses are depicted in Figure 3.7.

Missing chicks (those that disappeared from their nests) composed 50% of chick mortality (Fig. 3.8). Other causes of mortality included predation (34%), collapsed nests (11%), and unknown causes (5%).

1995

Of 201 chicks, 126 (63%) did not survive. As in 1994, half of all nestling mortality occurred within the first 5 days, with most mortality (23%) taking place on the 2nd and 3rd days and the least (3%) occurring on days 10 and 11.

Most nonsurviving chicks were missing (73%) or depredated (17%). The remaining chicks died either of unknown causes (9%) or as a result of a collapsed nest (1%).

NEST SUCCESS

1994

Nest success (percentage of nests in which one or more chicks fledged) was 28% (14 of 50 nests, Table 3.4).

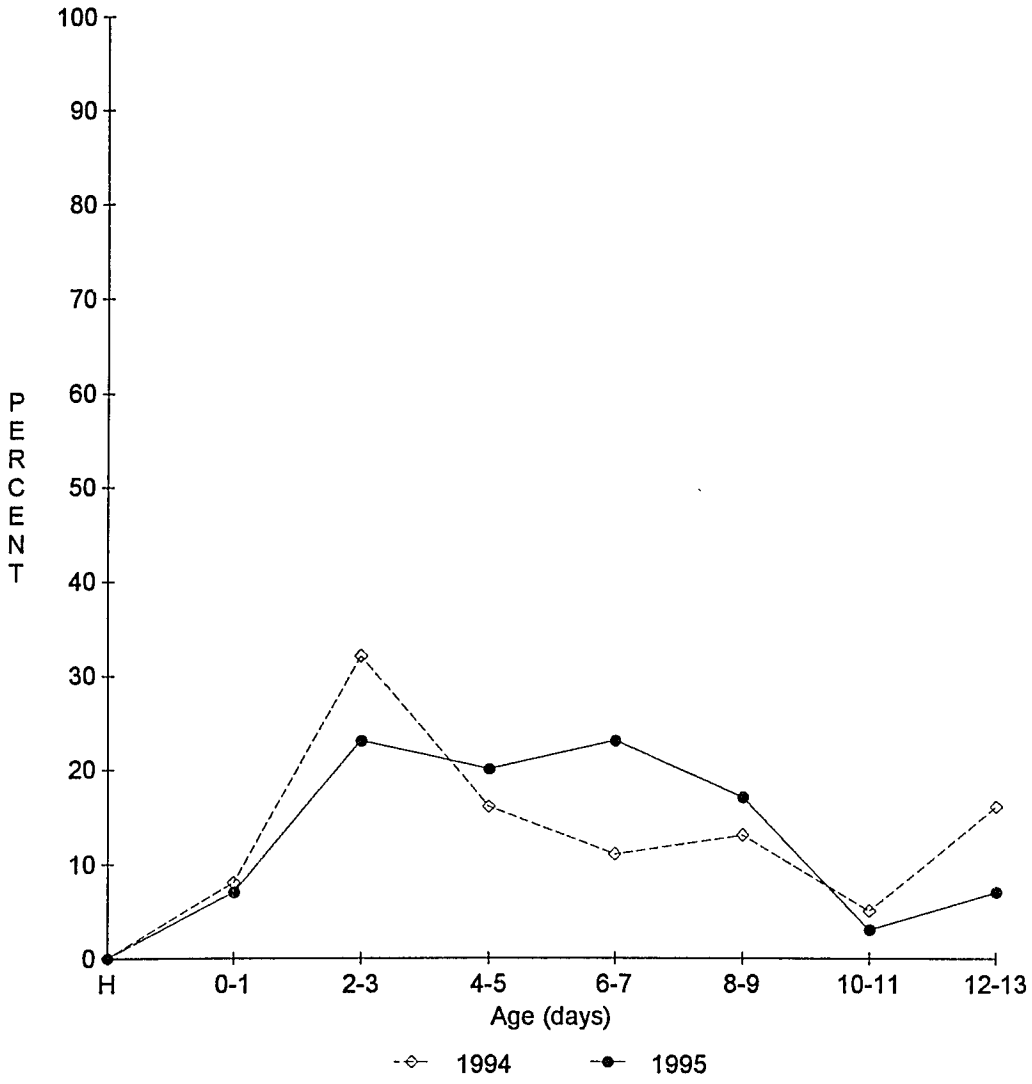


Figure 3.6. Distribution of total mortality of White-faced Ibis chicks (by days after hatch) in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994 (N = 38) and 1995 (N = 30).

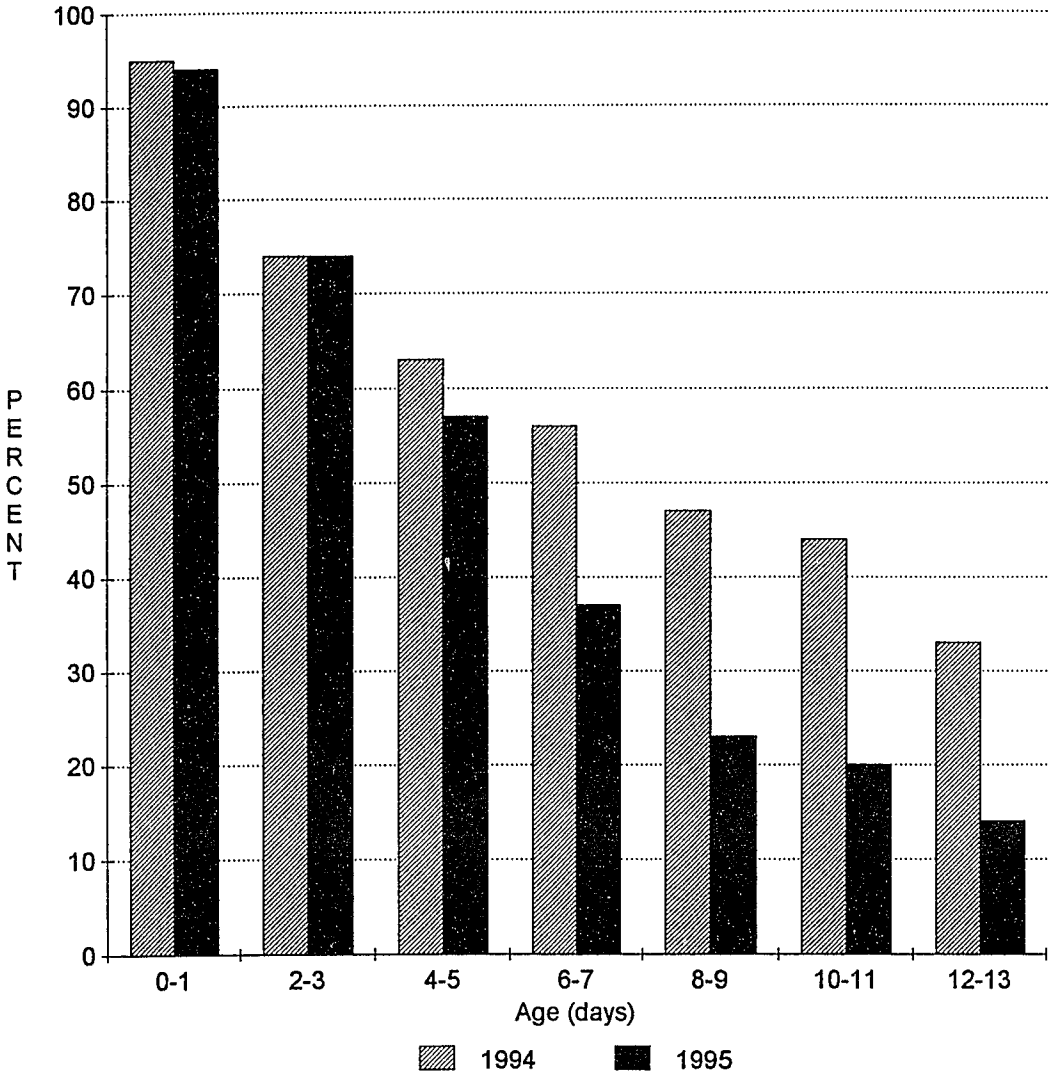


Figure 3.7. Frequency of survival of White-faced Ibis chicks (by days after hatch) in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994 (N = 38) and 1995 (N = 30).

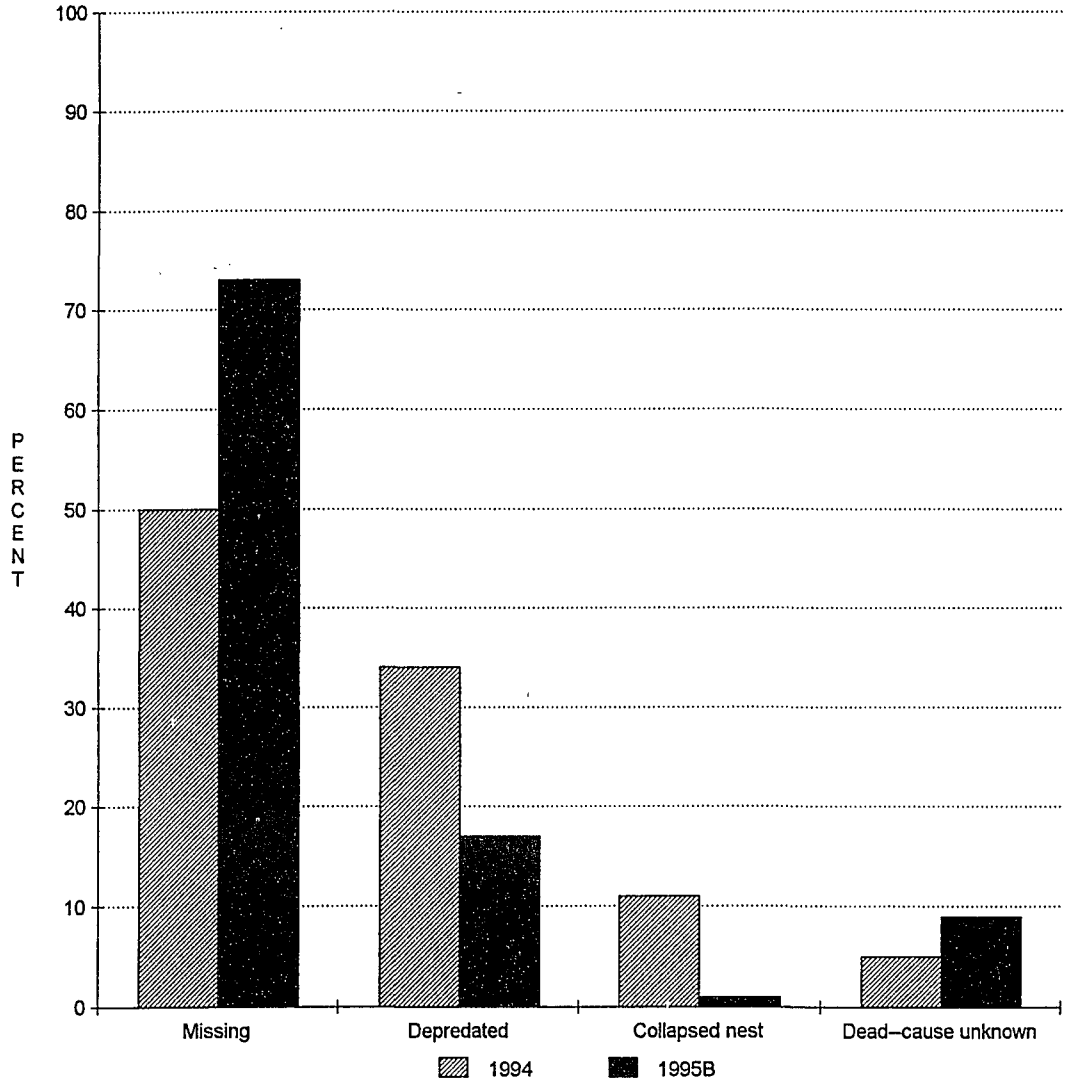


Figure 3.8. Fate of nonfledging White-faced Ibis chicks in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994 (N = 57) and 1995B (N = 201).

Table 3.4. Fate of White-faced Ibis nests in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994 and 1995.

Number of Nests	1994	1995A	1995B
Total	50	124	118
Lost during incubation	28	120	20[1]
Productive (at least 1 hatchling)	22	4	98
Lost during nestling stage	8	3	49
Successful (at least 1 fledgling)	14	1	49

[1] Minimum number. Seventy-seven nests were found in nestling stage.

Of the 36 unsuccessful nests, 28 were lost during the incubation stage and 8 during the nestling stage. During incubation, eggs were missing or depredated in 17 nests, 7 nests collapsed, and 4 were abandoned. During the nestling stage, chicks were missing or depredated in seven nests and one nest collapsed. No nests were abandoned during the nestling stage. Causes of all nest failures through 14 days of chick development are depicted in Figure 3.9.

Based on Mayfield's method (1961, 1975), the probability of a nesting attempt resulting in one or more chicks surviving 14 days was 12% (Table 3.5). Daily egg survival during incubation was 94%, and 21-day survival was 30%. Hatching probability was estimated at 90%, daily nest survival at 95%, and 14-day nest survival at 46%.

1995

Nest success was 42% (49 of 118 nests). Of the 69 unsuccessful nests, 20 were lost during the incubation stage and 49 were lost during the nestling stage. Most of the 20 unproductive nests were lost to predators (N = 17, 85%), 2 were abandoned (10%), and 1 collapsed (5%).

Chicks fledged in 49 of the productive nests. All 49 of the unsuccessful nests were lost to predators; none collapsed or were abandoned.

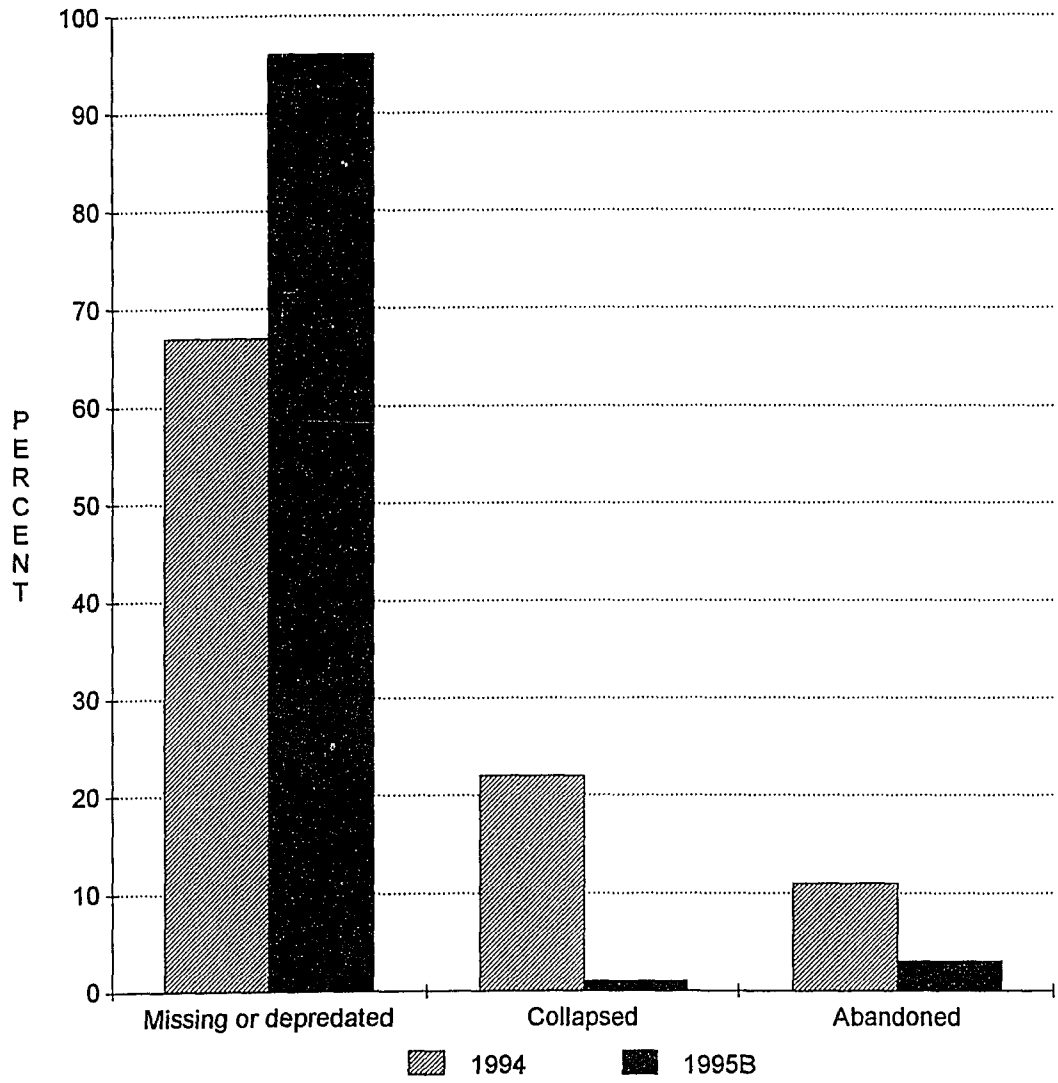


Figure 3.9. Fate of unsuccessful White-faced Ibis nests in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994 (N = 50) and 1995B (N = 118).

Table 3.5. Probability[1] (and interim calculations) that a nesting attempt will produce one or more fledged White-faced Ibis young in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994.

	Variables	1994 (N=50)
A.	Daily nest survival during incubation	0.94
B.	Nest survival during 21 days of incubation (A^{21})	0.30
C.	Probability of an egg hatching (hatching rate)	0.90
D.	Daily nest survival during nestling development	0.95
E.	Nest survival during 14 days of nestling development (D^{14})	0.46
F.	Probability of a nest producing one or more fledged young (B x C x E)	0.12

[1] Results calculated by the Mayfield (1961, 1975) method (interim calculations carried to four decimal places)

ANNUAL REPRODUCTIVE SUCCESS

1994

Approximately 1,473 chicks hatched (mean = 1.14 per nest) and 491 chicks fledged from 1,292 nests (Chapter II) for a mean of 0.38 fledged chicks per nest (Fig. 3.10, Table 3.3).

1995

Approximately 393 chicks hatched (mean = 0.63 per nest) and 149 chicks fledged from 622 nests for a mean of 0.24 chicks per nest attempt. Much of the colony suffered heavy predation and only 0.01 chicks fledged per nest in those sections whereas 0.64 chicks fledged per nest in the remaining 36% of the colony.

SUBSTRATE

1994

Of 50 nests studied, 45 were in black willow trees (90%), 3 were in buttonbush (*Cephalanthus occidentalis*) (6%), 1 in a tallowtree (*Sapium sebiferum*) (2%), and 1 in elderberry (*Sambucus canadensis*) (Table 3.6).

All 19 surviving chicks fledged from nests built in black willows (0.42 $\pm$ 0.10/nest, Table 3.7) which were significantly more successful than nests in other substrates ($t = -4.10$, $df = 44$, $P = 0.0002$). Two chicks hatched in a buttonbush nest, but neither fledged.

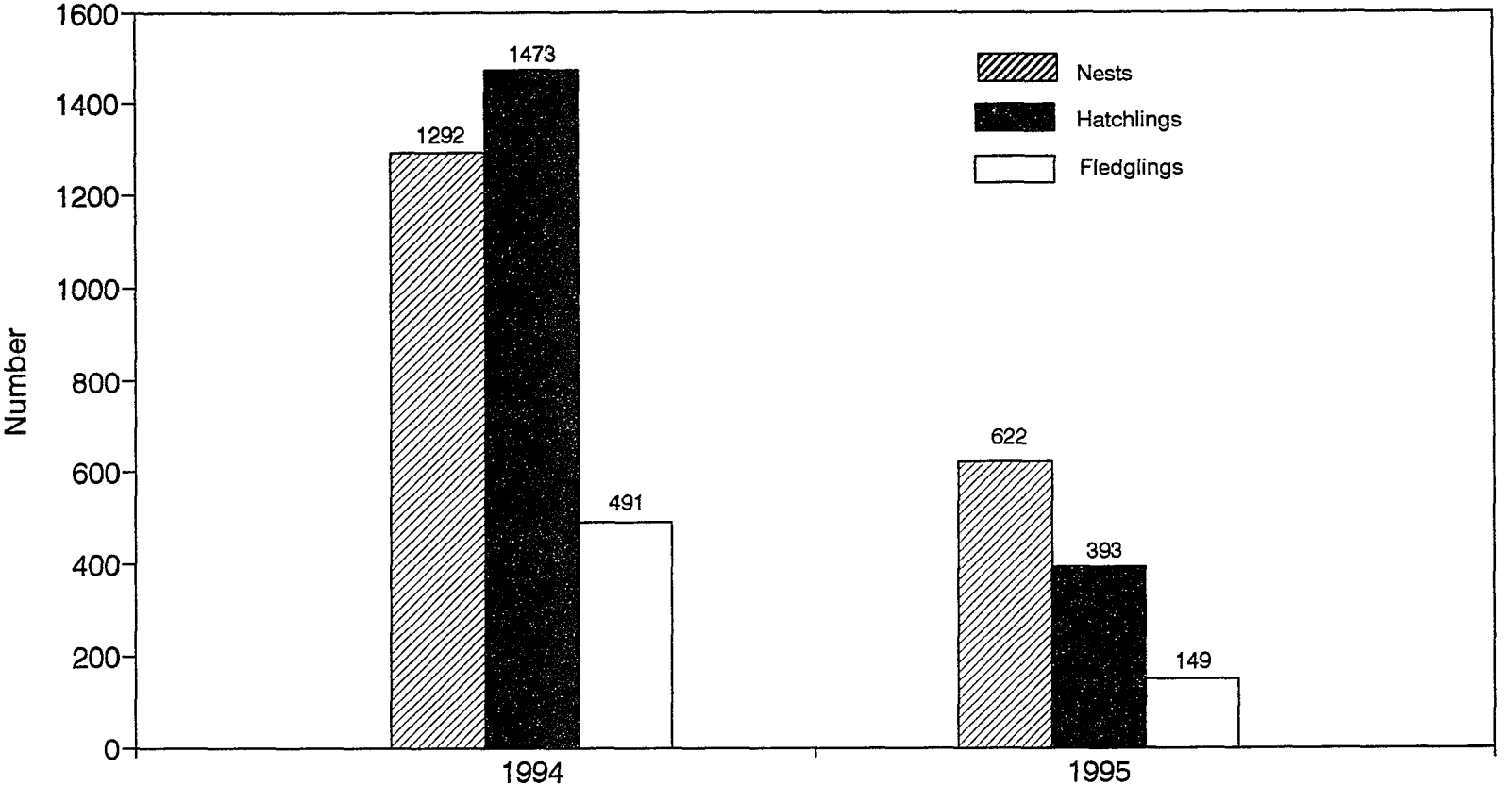


Figure 3.10. Estimated annual reproductive success of White-faced Ibises nesting in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994 and 1995.

Table 3.6. Location of White-faced Ibis study nests in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994 and 1995.

Nest parameter	1994	1995A[1]	1995B[2]
Number of nests	50	124	118
Substrate			
Buttonbush	3	3	1
Elderberry	1	7	0
Tallowtree	1	9	0
Black willow	45	105	117
Height			
Top	0	2	17
Middle	23	76	73
Bottom	27	46	28
Edge	ND*	27	60
Over water	26	0	0
Nearest-neighbor species			
White-faced Ibis	ND	65	39
Cattle Egret	ND	59	78
Tricolored Heron	ND	0	1
Nearest-neighbor distance (mean)			
White-faced Ibis	ND	2.02 m	2.65 m
Cattle Egret	ND	1.44 m	1.48 m
Tricolored Heron	ND	–	4.80 m

* ND = No data available

[1] Original nests lost as a result of predation in sections 5, 7, and 8

[2] Nests in sections 13 through 16

Table 3.7. Mean number (± 1 SE) of hatched and fledged White-faced Ibis chicks as a function of nest location. Analyses of variance (ANOVA) models were significant at the Alpha = 0.05 level.

Nest location	No. of nests	Hatched chicks	Fledged chicks	No. of nests	Hatched chicks	Fledged chicks
	----------1994----------			----------1995----------		
SUBSTRATE						
B. willows	45	1.22 ± 0.22	0.42 ± 0.10	117	1.71 ± 0.09	0.66 ± 0.08
Other	5	0.40 ± 0.40	0.00	1	1.00	0.00
		P = 0.2210	**P = 0.0002**			
HEIGHT						
Top		–	–	17	1.88 ± 0.22	1.06 ± 0.22[A]
Middle	23	1.17 ± 0.33	0.39 ± 0.15	73	1.70 ± 0.11	0.45 ± 0.09[B]
Bottom	27	1.11 ± 0.25	0.37 ± 0.12	28	1.61 ± 0.22	0.86 ± 0.16[A]
		P = 0.8775	P = 0.9132		P = 0.6758	**P = 0.0054**
EDGE						
Edge				60	1.88 ± 0.12	0.83 ± 0.11
Interior				58	1.52 ± 0.14	0.43 ± 0.10
					P = 0.0479	**P = 0.0074**

(table con'd)

Nest location	No. of nests	Hatched chicks	Fledged chicks	No. of nests	Hatched chicks	Fledged chicks
	1994			1995		
OVER WATER						
Inwater	26	1.81 ± 0.28	0.62 ± 0.15			
Dry	24	0.42 ± 0.20	0.13 ± 0.09			
		P = 0.0002	**P = 0.0073**			
NEIGHBOR						
CE				78	1.67 ± 0.11	0.64 ± 0.09
WFI				39	1.77 ± 0.16	0.64 ± 0.13
TH				1	2.00	0.00
					P = 0.6070	P = 1.0
DISTANCE*						
< 1 m				16	1.81 ± 0.19	1.31 ± 0.48
> 1 m				33	2.15 ± 0.11	1.64 ± 0.49
					P = 0.10	**P = 0.0335**

A, B Differences were statistically significant

* Distance from successful nests to nearest nesting neighbor (N = 49)

1995

Of the 118 nests, 117 were built in black willows and 1 in buttonbush. Black willow nests had means of 1.71 ± 0.09 hatched chicks and 0.66 ± 0.08 fledged chicks. One chick hatched in a buttonbush nest, but it was depredated.

HEIGHT

1994

Study nests ranged from 0.9 m to 3.6 m in height with an average of 2 m. Twenty-seven bottom nests (54%) were between 0.1 and 1.8 m and the other 23 were in the middle level between 1.81 and 3.6 m.

Heights of nests had no significant effect on nest success. Successful nests (N = 14) averaged 2.06 ± 0.17 m in height and unsuccessful nests (N = 36) averaged 1.99 ± 0.11 m.

In the bottom nests, 10 of 30 chicks fledged (0.37 ± 0.12/nest) and brood sizes ranged from zero to three. In middle nests, 9 of 27 chicks fledged (0.39 ± 0.15/nest), and brood sizes ranged from zero to five.

1995

Heights of study nests (those in which we could see the contents) ranged from 0.9 m to 5.8 m, and the mean was 2.7 m, but nests were as high as 7.5 m (Chapter I). Nests were dispersed through all three levels: 28 in the bottom level (24%), 73 in the middle (62%), and 17 in the top level (14%).

As in 1994, there were no significant differences in clutch sizes or numbers of hatched chicks among nests at different heights. However, top and bottom nests were significantly more successful (produced more fledglings) than middle nests ($F = 5.46$, $df = 115$, $P = 0.0054$). Top nests (3.6–5.4 m) had 32 chicks, of which 18 fledged (1.06 $\pm$ 0.22/nest) and 24 of 45 chicks fledged in bottom nests (0.86 $\pm$ 0.16/nest). Middle nests produced 124 chicks, of which 33 fledged (0.45 $\pm$ 0.09/nest).

EDGE

1994

Edge data were not collected in 1994.

1995

There were 60 "edge" nests (those within 1.8 m of the perimeter of the colony) and 58 others in the interior of the colony.

Clutch sizes of edge (2.30 $\pm$ 0.11) and interior nests (2.31 $\pm$ 0.10) did not differ significantly, but significantly more chicks hatched and fledged in edge nests. Edge nests had 113 chicks (1.88 $\pm$ 0.12/nest) compared with 88 chicks (1.52 $\pm$ 0.14/nest) in interior nests ($F = 1.16$, $df = 116$, $P = 0.0479$). Twice as many chicks ($N = 50$) fledged in edge nests than in interior ones ($N = 25$). Edge nests had a mean of 0.83 $\pm$ .11 fledglings per nest compared with 0.43 $\pm$ 0.10 fledglings in interior nests ($F = 1.27$, $P = 0.0074$).

WATER STATUS

1994

Significantly more young hatched in the 26 over-water nests (N = 47) than in the 24 over-land nests (N = 10). A mean of 1.81 ± 0.28 chicks hatched in over-water nests compared with 0.42 ± 0.20 chicks in over-land nests ($t = 3.96$, $df = 48$, $P = 0.0002$). Sixteen chicks fledged in over-water nests (0.62 ± 0.15/nest) compared with three fledglings (0.13 ± 0.10/nest) in over-land nests for another significant difference ($t = 2.82$, $df = 41$, $P = 0.0073$).

Following Mayfield's method (1961, 1975), I calculated the probabilities that over-water and over-land nesting attempts would result in at least one 14-day-old chick. Over-water nests had 97% daily egg survival and 95% daily nestling survival rates, resulting in a total probability of 25%. Over-land nests had daily survival rates of 91% and 94%, respectively, for a total probability of 6% (Table 3.8).

1995

No data were available because all the trees were on dry land.

Table 3.8. Probability[1] (and interim calculations) that nesting attempts over water and over land will produce one or more fledged White-faced Ibis young in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994.

	Over water[2] (N=26)	Over land[3] (N=24)
A. Daily nest survival during incubation	0.97	0.91
B. Nest survival during 21 days incubation (A^{21})	0.55	0.14
C. Probability of an egg hatching (hatching rate)	0.90	0.91
D. Daily nest survival during nestling development	0.95	0.94
E. Nest survival during 14 days of nestling development (D^{14})	0.51	0.44
F. Probability of a nest producing one or more fledged young (B x C x E)	0.25	0.06

[1] Results calculated by the Mayfield (1961, 1975) method (interim calculations carried to four decimal places)

[2] Nest-trees in water

[3] Nest-trees on land

NEAREST-NEIGHBOR SPECIES

1994

Nearest neighbor data were not collected in 1994.

1995

Cattle Egrets were the most frequent nesting neighbors of White-faced Ibises (66%), followed by conspecifics (33%), and one Tricolored Heron (*Egretta caerulea*).

Clutch sizes and numbers of hatched and fledged chicks did not differ significantly as a result of nearest-neighbor species. Ibis nests with egret neighbors had a mean of 1.67 ± 0.11 chicks per nest, and those with ibis neighbors a mean of 1.77 ± 0.16 chicks per nest. The percentage of fledglings was identical (0.64/nest) regardless of neighboring species; the 78 nests closest to egret neighbors had 50 fledglings, whereas 39 nests with conspecific neighbors fledged 25 chicks.

NEAREST-NEIGHBOR DISTANCE

1994

Nearest-neighbor distances were not collected.

1995

The mean distance to neighboring Cattle Egret nests (1.48 ± 1.0 m) was significantly shorter than distances to other White-faced Ibis neighbors (2.65 ± 1.5 m), and to the Tricolored Heron (4.8 m).

Mean distance to nearest neighbor from successful nests (1.98 ± 0.18 m) was not significantly different than distances from unsuccessful nests (1.83 ± 0.16 m). However, when I analyzed results of the 49 successful nests, I discovered that the 16 nests with near neighbors (those within 1 m) fledged significantly fewer chicks ($T = -2.19$, $df = 47$, $P = 0.0335$) than the 33 nests with distant neighbors (beyond 1 m). Twenty-one chicks fledged in nests with near neighbors (1.31 ± 0.48/nest) compared with 54 chicks in nests with distant neighbors (1.64 ± 0.49).

COMPARISON OF 1995A AND 1995B NEST-SITES

Of 124 nests chosen in the first three randomly selected sections in 1995 (1995A), all but 4 were depredated in a 2-week span, so I selected 118 other nests in sections 13 through 16 (1995B) to continue the study. Results of Chi-square tests for homogeneity revealed significant differences between nests in 1995A and 1995B for all four nesting parameters tested: substrate, nest height, proximity to edge, and nearest-neighbor species.

In 1995B more nests were in black willows (Contingency Table, $X^2 = 17.51$, $df = 3$, $P = 0.001$, $N = 242$), were in higher locations (2.7 m vs. 2.2 m, $T = -4.94$, $df = 201$, $P = 0.001$, $N = 242$), were along the edge rather than the interior of the colony (Contingency Table, $X^2 = 22.20$, $df = 1$, $P = 0.001$, $N = 242$), and were

nearer Cattle Egret nests (33% vs. 52%) than conspecific nests (Contingency Table, $X^2 = 9.99$, df = 2, P = 0.007, N = 242).

There was little difference in overstory and understory vegetation (Chapter I). The basal area was 11.0 m^2 per ha in 1995A compared with 10.3 m^2 per ha in 1995B. Understory plants were similar.

DISCUSSION

EGG MEASUREMENTS

Average egg measurements (in millimeters) (50.9 x 36.2) were similar to those (51.2 x 36.0) Belknap (1957) found 40 years ago in Louisiana. However, they were smaller than those measured in Utah: 51.9 x 37.0 and 51.4 x 36.8 (Kaneko 1972) and 52 x 36.7 (Kotter 1970).

CLUTCH SIZE

Clutch size of the White-faced Ibis is usually three or four eggs (Ryder and Manry 1994). Therefore, the clutch of six eggs found in 1994 may have been an intraspecific "dump nest"; a nest in which two females laid eggs.

Clutch size appears to increase with latitude, most likely as a result of seasonal differences in food resources (Lack 1954). Lack hypothesized that clutch size is determined by the maximum number of chicks parents can provide for. Thus he attributes latitudinal differences in clutch sizes to the greater amount of food available

and the increased time (due to the longer days) available to forage in more northern latitudes (Lack 1947, 1948, 1954).

Results from my study and studies of other Ciconiiformes, Little Blue Herons (*Egretta caerulea*) (Meanley 1955, Jenni 1969) and Cattle Egrets (Jenni 1969), lend support to Lack's hypothesis.

In 1994 clutch sizes ranged between one and six eggs with a mean of 2.8 eggs, and in 1995 clutch sizes averaged 2.6 eggs (Table 3.3). In an earlier study in Louisiana, 16 clutches had a mean of 3.06 eggs with a range of two to four eggs (Belknap 1957). Average clutch sizes in Texas, in an area with a slightly more southerly latitude than LNWR, were similar to those in our study: 2.71 and 2.54 (King *et al.* 1980), and 2.84 and 2.98 (Custer and Mitchell 1989).

However, in more northern latitudes, clutches were larger. They averaged 3.35 and 4.14 in seven colonies in Colorado (Schreur 1987), 2.90 and 3.55 in six subcolonies in Nevada (Henny and Herron 1989), and 3.69 (Kotter 1970), 3.17 (Kaneko 1972), 3.4 (Capen 1977), 2.98 (Alford 1978), and 3.2 (Steele 1980, 1984) in Utah. These differences seem to be true latitudinal differences, but they may be overstated because extensive predation suffered in ibis colonies in Louisiana may have caused investigators to understate original clutch sizes.

King (*et al.* 1980) has suggested that smaller clutch sizes in Texas (as compared with Colorado, Nevada, and Utah) may actually reflect premature egg losses resulting from weak eggshells of pesticide-laden eggs, rather than true latitudinal differences. However, the fact that lower clutch sizes (with no evidence of egg loss due to pesticides) were observed in my study may provide further evidence of true latitudinal differences.

HATCHING RATE

Hatching rates were very high both years (90% in 1994 and 93% in 1995), indicating that pesticides were not a significant factor in egg failures in this colony. Evidence of pesticide-related failures (thin, cracking, and crushed eggs) was found in previous studies of the White-faced Ibis (Capen 1977, King *et al.* 1980, Steele 1980, 1984, Henny and Heron 1989). Although DDT has been banned in the United States, some nesting ibises (those in the Great Basin states) are still exposed to it on their wintering grounds in Mexico, where there are no pesticide regulations (Ryder 1967).

HATCHING SUCCESS

Hatching success was understandably lower than hatching rates because some eggs were lost to predation and other causes. Except for 1995B (74%), rates found in my study (41% in 1994 and 1% in 1995A) were lower than

most reported in Utah: 66% (Kotter 1970), 62% (Kaneko 1972), 56% (Alford 1978), and ranging from 3 to 87% (Steel 1980).

NEST PRODUCTIVITY

The most representative nest productivity rates in my study were 44% in 1994, and 1% in 1995A; both were lower than rates observed in most colonies in Utah: 66% (Kotter 1970), 69% (Kaneko 1972), 4 to 85% (Capen 1977), 64% (Alford 1978), and 3 to 94% (Steele 1980). The differences in nest productivity between colonies in Utah and the one I studied is a reflection of the more extensive predation sustained by the black willow colony in Lacassine.

FLEDGING SUCCESS

Hatching order was a major factor in chick survival. A-chicks, having hatched at least 1 to 2 days earlier (Chapter IV), were larger and stronger than their siblings and seemed to be more aggressive and better able to defend themselves. During the 2 years of my study we found 16 chicks that died from head injuries. In five of these nests, remaining brood-mates were still alive despite sustaining severe bill injuries from an intense fight. All injured but surviving siblings were A-chicks.

Researchers studying Cattle Egrets (Fujioka 1985), Little Egrets (*Egretta garzetta*) (Inoue 1985), and egrets and herons (Mock and Parker 1986) report similar findings;

in addition to demonstrating greater food-handling capabilities, the oldest chicks were stronger and more aggressive in sibling interactions.

In two studies of nesting ibises in Utah, researchers calculated 7-day, rather than 14-day, survival rates. In order to compare my results with those studies I also calculated 7-day survival rates. Using this time frame, 35 of 57 chicks (61%) fledged in 1994, and 15 of 35 chicks (43%) with known hatching order fledged in 1995. These figures are considerably lower than the 80% cited by Kotter (1970) and the 88% by Alford (1978).

MORTALITY

In both years, after declining through days 10 and 11, mortality increased on days 12 and 13 (Fig. 3.6). I speculate that the escalating rate beginning on days 12 and 13 resulted from chicks leaving the protection of their nests and venturing further away. We saw Cattle Egret adults peck chicks that wandered too close to their nests. Also, when chicks were about 2 weeks old, adults left them unattended for longer periods, making them more vulnerable to predation.

The majority of egg and chick losses resulted from predation, an outcome that lends credence to the premise that predation is the primary selective pressure causing nest loss (Lack 1954, Ricklefs 1969). Nests also failed due to their collapse or abandonment and, possibly, to a

smaller extent because of starvation and the effects of investigator disturbance.

Eggs and chicks were lost to both terrestrial and aerial predators. Terrestrial predators included mink (*Mustela vison*) and raccoons (*Procyon lotor*). Also, alligators, rat snakes (*Elaphe obsoleta*), cottonmouths (*Agkistrodan piscivorus*), and fire ants were abundant. Aerial predators included Black-crowned Night-Herons (*Nycticorax nycticorax*), Yellow-crowned Night-Herons (*Nycticorax violaceus*), Boat-tailed Grackles (*Quiscalus major*), and a Great Horned Owl (*Bubo virginianus*).

Although avian predators and snakes probably significantly reduced numbers of eggs and chicks each year, I believe that raccoons or mink were largely responsible for the extensive losses that occurred within 2 weeks, beginning 21 June 1995. Mustelids and raccoons are known to "raid colonies, especially when water levels are low" (Ryder and Manry 1994), and raccoons have destroyed entire nesting colonies (Lopinot 1951, Burger and Hahn 1977, Southern and Southern 1979, Southern *et al.* 1985). I saw one mink in the colony and two raccoons on the levee, and found raccoon tracks in the site, and scat in one depredated nest. There was significantly greater predation in 1995 when there was no water in the colony, a factor that would affect only terrestrial, not aerial, predators. Sixteen chicks died from massive head injuries

that might have been caused by mink or by long-tailed weasels (*Mustela frenata*) and/or raccoons that engage in surplus killing (Kotter 1970). Weasels have been known to "eat only the brains" of small birds (Lowery 1974). In five of these nests the remaining brood-mates suffered severe bill injuries, an indication that a struggle had taken place. In each case the surviving sibling was an A-chick, which at first led me to consider the possibility of siblicide. However, due to the extensive damage and the fact that injuries occurred overnight, while adults were on their nests, I have excluded this possibility. Some chicks with broken and twisted bills also had large holes (approximately 1 cm in diameter) in their torso. These injuries might implicate a nocturnal avian predator such as a Black-crowned Night-Heron.

The remaining causes of nest failure were less consequential than predation (Fig. 3.9). Eight nests (16%) in 1994 and only one (5%) in 1995 collapsed. All but one nest collapsed during the incubation stage. It seems plausible that the one nest that collapsed during the nestling stage may have been depredated. Seven of the eight collapsed nests in 1994 were at the western end of the colony (sections 66 and 69). Because these sections consisted of smaller trees, nests had less structural support and less protection from the elements, evinced by the fact that six nests in those sections collapsed

following a major wind storm. Alternative, but not mutually exclusive, explanations are that less experienced birds with lesser nest-building skills nested in these sections, or that the best breeding habitats were selected by dominant individuals and these marginal nest-sites, with a lower probability of success, were relegated to the subdominant birds (as in the ideal-free distribution hypothesis). No birds nested in these sections in 1995.

Few nests (four in 1994 and two in 1995) seemed to have been abandoned. Ibises did not normally abandon nests as long as one viable egg or chick remained; none were abandoned during the nestling stage. We found the head of an adult ibis under an abandoned nest, which may be an indication that predation may have been the actual cause of some lost nests that were classified as "abandoned." However, some nests listed as "collapsed" might actually have been abandoned, and the nest material subsequently taken by other nesting birds.

Starvation did not seem to be an important mortality factor in my study. Capen (1977) estimated that "differential starvation" reduced ibises' brood size as a result of hatching asynchrony, but I saw few indications of starvation (Chapter IV). Two chicks in 1994 and 11 in 1995 were found dead of unknown causes, but all except 1 were of average size for their ages. One, a D-chick, either starved or was trampled by three older brood-mates.

NEST SUCCESS

Nest success in 1994, when chicks fledged in 28% of all nests, was higher than the probability of nest success (12%) as calculated according to Mayfield (1961, 1975). This was not unusual because I found nests in various stages of incubation. Observed success in such a sample would be greater than the true nesting success, which would reflect lost nests that were not included in my results.

ANNUAL REPRODUCTIVE SUCCESS

For a species to survive, reproduction must replace adult mortality. Ryder (1967) compiled a composite life table of the White-faced Ibis based on 111 bands recovered from 2,708 nestlings banded in Utah between 1916 and 1957. Mean annual mortality was 50%, declining from 54% the 1st year to 43% thereafter. From data in the life table, Ryder concluded "*if* all ibises breed in their first year and *if* each pair raises an average of 1.9 young to August 1 (the start of the banding year), the mortality rates . . . would permit a stable population." The "*ifs*" are critical because ibises most likely begin breeding at 2 or 3 years of age (Palmer 1962, Capen 1977), not in their 1st year, and reproductive rates in both years of my study (0.38 fledglings in 1994 and 0.24 in 1995) did not approach the requisite annual average rates (1.9 chicks per nest).

The coastal areas of Louisiana are believed to support many White-faced Ibis breeding colonies (Ryder 1967, Ryder and Manry 1994). However, if the reproductive rates reported in my study are typical, ibises could not sustain a stable local population.

According to band recovery data, the oldest ibis in Ryder's (1967) study was 9 years of age. The oldest ibis documented in the wild was 14.5 years of age (Clapp *et al.* 1982), and the oldest captive ibis lived for 14 years (Stott 1948). For many species, survival during early years is more difficult than in later years as a result of inexperience and predation. In comparison with other Ciconiiformes, however, ibises have a lower first-year mortality rate and a higher mortality rate in later years (Ryder 1967). Adult ibises face a variety of threats. Occasionally mammals such as raccoons, coyotes (*Canis latrans*), mink, and weasels kill adults (Kotter 1970, Capen 1977, Ryder *et al.* 1979), and natural causes such as botulism have sickened and caused the deaths of ibises in Utah (Ryder and Manry 1994). Man, however, is the ibis's primary adversary, because he is responsible for diverting water from wetlands (Herron and Lucas 1978, Ryder *et al.* 1979, Henny and Herron 1989); illegal hunting (Bent 1926, Ryder 1967); the spread of potentially harmful pesticides (Capen 1977, Steel 1980, Henny and Herron 1989); the introduction of toxicants (mercury and selenium), as

detected in nesting ibises in Nevada (Henny and Herron 1989); the importation of exotics like nutria (*Myocaster coypus*), which have damaged nesting vegetation in Louisiana (Belknap 1957); and habitat destruction as a result of cattle grazing and trampling (Herron and Lucas 1978).

SUBSTRATE

All successful nests were built in black willows. Nest heights in buttonbush, elderberry, and tallowtrees were on average lower than those in black willow nests. Their average height was 1.8 m, much lower than the average height of all study nests (mean = 2.7 m).

The few buttonbush in the black willow colony were single, isolated plants, unlike the dense stands found in the buttonbush colony (Chapter II). Compared with black willows, buttonbush and elderberry provided much weaker foundations, making nests more vulnerable to heavy use and high winds. In addition, the low, spreading growth patterns of these bushes rendered nests more vulnerable to terrestrial depredation. We saw a rat snake (*Elaphe obsoleta*) in a buttonbush nest that contained two chicks.

Although there appeared to be significant differences in fledging success as a result of nest substrate, the sample size of nests in trees other than black willows was very small; chicks hatched in only one of these nests each year.

HEIGHT

Because survival rates in 1994 were similar in middle and bottom level nests, predation of middle nests (presumably incurred by a combination of terrestrial and aerial predators) must have been comparable to losses in the lower nests (caused by terrestrial predators, particularly alligators).

I believe alligators took at least six bottom nests (12% of all study nests) and their contents (seven chicks and five eggs). According to the refuge's game warden, this height can be easily reached by a large alligator (C. Pugh pers. comm.), and we witnessed one alligator splashing back into the water with the remains of a nest in its jaws. As other evidence, alligators are reputed to develop specialized feeding habits (R. Chabreck pers. comm.), and all six nests were missing on the same day.

In 1995 more chicks fledged in top and bottom nests than in middle nests. I assume that adverse weather and aerial predators were the major factors contributing to failures in top nests, whereas bottom nests were more vulnerable to climbing predators (snakes and mammals).

Middle nests, which fledged only half as many chicks as top and bottom nests, must have sustained compounded losses resulting from exposure to both aerial and terrestrial predators.

Unlike 1994, we did not observe any signs of alligator predation in 1995, probably because of the low water levels.

EDGE

Researchers studying the influence of nesting location (edge or interior) on reproduction in colonially nesting birds have generally found higher success in centrally located nests. In a few studies there was no difference in success (Knopf 1979, Ryder and Ryder 1981, Kilpi 1988), but in most cases nests on the edges of colonies had the lowest breeding success; such was found in studies of Black-headed Gulls *(Larus ridibundus)* (Patterson 1965), Kittiwakes *(Rissa tridactyla)* (Coulson 1968), Ring-billed Gulls *(Larus delawarensis)* (Dexheimer and Southern 1974), Adelie Penguins *(Pygoscellis adeliae)* (Tenaza 1991), and Eared Grebes *(Podiceps nigricollis)* (Boe 1994). The difference in breeding success has been attributed to the fact that interior nests were less vulnerable to aerial predation.

In contrast to those studies, I found significantly more hatched and fledged chicks in edge nests, although they were subjected to adverse weather conditions (wind, rain, and sun exposure) and aerial predators including Boat-tailed Grackles, Great Horned Owls, Black-crowned

Night-Herons and Yellow-crowned Night-Herons (*Nycticorax violaceus*). I believe edge nests were more successful because terrestrial predators, probably mink or raccoons, consumed more eggs and chicks than aerial predators. This was an atypical colony site; a long and narrow strip of land surrounded by water. Having entered the colony, a mammal would presumably take from the most accessible nests it encountered (those most centrally located over dry land), rather than those on the edges, especially those over water.

In related studies of the White-faced Ibis in Utah, nests were concentrated in the center of the colonies with fewer nests around the periphery (Kotter 1970, Kaneko 1972). Nest-sites in my study were evenly divided with 58 nests in the center and 60 nests around the perimeter. They did not follow a pattern similar to those in Utah, probably because the shape of the black willow colony created much more edge than was typically found in more circular colonies.

WATER STATUS

In 1994 the numbers of hatched and fledged chicks were significantly greater in over-water nests. The overall probability of an egg resulting in a 14-day-old chick was 0.25 for over-water nests and 0.06 for over-land nests. The most critical difference between over-water and over-land nests occurred during the incubation stage,

indicating that eggs were more vulnerable to predators than nestlings were.

Other researchers have found that terrestrial predators, primarily raccoons, mink, and weasels were most likely to enter White-faced Ibis colonies to consume eggs, chicks, and occasionally adults, when water levels were low (Kotter 1970, Steele 1980, Kingery 1980, 1988, Capen 1977, Ryder *et al.* 1979). Studies of other colonial waterbirds have led to similar conclusions. Raccoons and other mammalian predators were prevented from accessing and preying upon colonies surrounded by water but were active in colonies where the surrounding water had dried (Lopinot 1951, Rodgers 1987, Frederick and Collopy 1989). Fleming (1975) detected a significantly higher incidence of raccoon predation of alligator eggs in dry years in southwestern Louisiana, when 45% of the eggs were destroyed. In contrast, no predation occurred when prolonged high water levels restricted raccoon movements.

I suspect that higher water levels contributed to greater nest success in 1994. The mean of 0.38 fledglings per nest in 1994 (N = 50) dropped to 0.24 in 1995 (N = 242), when the colony-site was dry.

Concurrent with the high water in and around the colony-site in 1994 were more (and larger) alligators. The combination of high water and numerous alligators in 1994 probably served as a deterrent to mammalian

predators, which became prey themselves when in the colony, and when attempting to swim to and from the colony.

Although a threat to individual waterbirds, the presence of alligators probably had a positive affect on the colony by limiting the number, and consequently the detrimental impact, of mammalian predators.

NEAREST-NEIGHBOR SPECIES

Nearest-neighbor species generally conformed with the percent of abundance of each species in the colony. At their population peak, 61% of all nesting birds were Cattle Egrets, 36% were White-faced Ibises, and 3% were a variety of other colonially nesting wading birds. Similarly, the majority of nearest neighbors of ibises were Cattle Egrets (66%), ibises (33%), and other wading birds (1%).

My findings were similar to those in studies in Utah where ibises exhibited no preferences for nearest-neighbor species (Kotter 1970, Kaneko 1972, Capen 1977). But they differed from a study in Argentina and Texas. Burger and Miller (1977) concluded that White-faced Ibises exhibited a preference for conspecific neighbors, and suggested that ibises may "actively defend space around their nests from other species" while permitting closer nesting by other White-faced Ibises. Because egrets continued to initiate nesting after ibises had established their nests, these

distances may reflect the egrets' preferred nesting distances, rather than those of ibises. If ibises originally selected nest-sites with conspecific neighbors, they did not aggressively defend them against Cattle Egret neighbors.

NEAREST-NEIGHBOR DISTANCE

Distances from White-faced Ibis nests to those of their nearest conspecific neighbors (mean = 2.65 m) were significantly greater than distances to nests of Cattle Egret neighbors (mean = 1.48 m). However, neighbor proximity in my study may merely reflect the abundance of Cattle Egrets, because there were approximately twice as many egrets as ibises nesting in the black willow colony.

Distances to nearest-neighbor nests are indications of the nesting area defended by adults (Clark and Evans 1954). Belknap (1957), Kotter (1970), and I observed ibises defending an area of about 1 m around their nests. Significantly more of the 49 successful nests were those with distant neighbors (67%,) rather than near (within 1 m) neighbors (33%). Chicks with near neighbors may have suffered more injuries and deaths from neighbors. We observed attacks on ibis chicks who had strayed into other nests. To a lesser extent, adults may have been injured while protecting their territory. Adults with near neighbors may face conflicting demands--to spend time away from the nest collecting food for chicks, and to remain on

the nest to protect chicks from possible injury or death from near neighbors.

It should be noted that these results may not be representative of previous years. As I recall, average distances to neighbors were shorter in 1994, when there were approximately twice as many ibis (1,292 vs. 622) and Cattle Egret nests (2,322 vs. 1,057).

COMPARISON OF 1995A AND 1995B NEST-SITES

Although results of these comparisons indicated significant differences between nesting parameters and minor differences in the overstory, I do not consider the differences to be of such magnitude that they explain the severe loss of nests within 1995A sections as well as in most of the colony. For example, I do not think the significant difference in the number of black willow nests (the most successful substrate) is important because 104 of the 105 depredated nests in 1995A were also in black willows.

I believe 1995B nests were spared the most severe predation for one or more of the following reasons: (1) the "swamping effect" (Nisbet 1973); there was such a volume of eggs that some, clumped within a few sections, hatched before they were depredated; (2) an alligator may have taken a principal predator; or (3) the conspicuous presence of a very large alligator (about 4 m in length)

that actively patrolled these sections may have deterred predators.

EFFECTS OF INVESTIGATOR DISTURBANCE

Most researchers have found that investigator disturbance has adverse effects on reproductive success of wading birds (Blaker 1969, Jenni 1969, Wolford and Boag 1971, Rodgers and Smith 1991). A few researchers, however, have found otherwise (Goering and Cherry 1971, Frederick and Collopy 1989). Although there are conflicting conclusions, the general consensus holds that investigator visits occurring early in the reproductive cycle (during nest construction and egg laying) adversely affect nesting birds, although the magnitude is not well documented (Frederick and Collopy 1989, Jenni 1969, Tremblay and Ellison 1979, Ryder and Manry 1994). Detrimental effects include avoidance, inhibited laying, increased nest abandonment, and egg losses as a result of adults' "panic" departures from nests (Cairns 1980). When adult birds leave their nests unattended for long periods there may be several additional harmful results: (1) egg embryo and chick losses due to overheating or overchilling (Parnell and Shields 1990); (2) older chicks leaving their nest and becoming lost, entangled in vegetation, or killed (Parnell and Shields 1990); and (3) increased susceptibility to depredation (Ellison and Cleary 1978). Bildstein (1993) found that Black-crowned Night-Herons

"plucked" nestlings from nests temporarily unprotected while he and his students were working in a wading bird colony.

In order to minimize the impact of our presence in the colony, we entered the colony during the late stages of incubation and worked quickly and quietly so nests were unattended for only a few minutes. Although adults left their nests as I approached, as they became accustomed to our presence they remained nearby and returned promptly as we moved away.

We did not witness any predation of unoccupied nests, and I do not believe egg or chick loss resulted from exposure, possibly because our visits were short, but principally because of the shade provided by the extensive canopy of the black willows.

Although four chicks regurgitated their meals after being handled, no chick lost more than one meal during the entire study, and each was still alive on the following visit (Chapter IV). Therefore, it is not likely that we caused the starvation of any chicks.

I do not believe that the massive predation in 1995 can be attributed to investigator disturbance because it was widespread throughout the colony, which included sections we had not entered.

However, in spite of my precautions, I am certain my activities caused some incidental losses, primarily to a

few large chicks who jumped from their nests to other trees or to the ground.

LITERATURE CITED

Alford, E.H. 1978. Early nesting by White-faced Ibis in relationship to habitat: an adaptive advantage. M.S. Thesis, Brigham Young University, Provo, UT. Unseen.

Belknap, H.W. 1957. Observations on the White-faced Ibis (*Plegadis chihi*) in Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge, LA.

Bent, A.C. 1926. Life histories of North American marsh birds. U.S. Natl. Mus. Bull. pg. 135.

Bildstein, K.L. 1993. White Ibis: wetland wanderer. Smithsonian Institution Press, Washington, D.C.

Blaker, D. 1969. Behavior of the Cattle Egret (*Ardeola ibis*). Ostrich 40:75-129.

Boe, J.S. 1994. Nest site selection by Eared Grebes in Minnesota. Condor 96:19-35.

Burger, J., and D.C. Hahn. 1977. Crow predation on Black-crowned Night-Heron eggs. Wilson Bull. 89:350-351.

Burger, J., and L.M. Miller. 1977. Colony and nest-site selection in White-faced and Glossy Ibises. Auk 94:664-676.

Cairns, D. 1980. Nesting density, habitat structure and human disturbance as factors in Black Guillemot reproduction. Wilson Bull. 92:352-361.

Capen, D.E. 1977. The impact of pesticides on the White-faced Ibis. Ph.D. Dissertation, Utah State University, Logan, UT.

Clapp, R.B., M.K. Klimkiewicz, and J.H. Kennard. 1982. Longevity records of North American Birds: Gaviidae through Alcidae. J. Field Ornithol. 53:81-124.

Clark, P.J., and F.C. Evans. 1954. Distance to nearest neighbor as a measure of spatial relationships in populations. Ecology 13:444-453.

Coulson, J.C. 1968. Differences in the quality of birds nesting in the center and on the edges of the colony. Nature 217:478-479.

Custer, T.W., and C.A. Mitchell. 1989. Organochlorine contaminants in White-faced Ibis eggs in southern Texas. Colonial Waterbirds 12:126-129.

Dexheimer, M., and W.E. Southern. 1974. Breeding success relative to nest location and density in Ring-billed Gull colonies. Wilson Bull. 86:288-290.

Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. The birder's handbook: a field guide to the natural history of North American birds. Simon & Schuster, Inc., New York, NY. 785 pp.

Ellison, L.N., and L. Cleary. 1978. Effects of human disturbance on breeding of Double-crested Cormorants. Auk 95:510-517.

Fleming, D.M. 1975. Movement Patterns of the coastal marsh raccoon in Louisiana and notes on its life history. M.S. Thesis, Louisiana State University, Baton Rouge, LA.

Frederick, P.C., and M.W. Collopy. 1989. The role of predation in determining reproductive success of colonially nesting wading birds (Ciconiiformes) in the Florida Everglades. Condor 91:860-867.

Fujioka, M. 1985. Sibling competition and siblicide in synchronously-hatched broods of the Cattle Egret *Bubulcus ibis*. Animal Behaviour 33:1228-1242.

Gill, F.B. 1990. Ornithology. W.H. Freeman, New York, NY.

Goering, D.K., and R. Cherry. 1971. Nestling mortality in a Texas heronry. Wilson Bull. 83(3):303-305.

Henny, C.J., and G.B. Herron. 1989. DDE, selenium, mercury, and White-faced Ibis reproduction at Carson Lake, Nevada. J. Wildl. Manage. 53:1032-1045.

Herron, G.B., and P.A. Lucas. 1978. Population surveys, species distribution, and key habitats of selected nongame species. P-R Rep., Federal Aid Proj. W-53-R, Nevada Dept. Wildl., Reno. In Ryder, 1990.

Inoue, Y. 1985. The process of asynchronous hatching and sibling competition in the Little Egret *Egretta garzetta*. Colonial Waterbirds 8:1-12.

Jenni, D.A. 1969. A study of the ecology of four species of herons during the breeding season at Lake Alice, Alachua County, Florida. Eco. Monogr. 39:245-270.

Kaneko, K.D. 1972. Nesting of the White-faced Ibis (*Plegadis chihi*) on Utah Lake. M.S. Thesis, Brigham Young University, Provo, UT.

Kilpi, M. 1988. Territory type in relation to onset of breeding in the Herring Gull (*Larus argentaus*): does the early bird get the worm? Colonial Waterbirds 11:95-99.

King, K.A., D.L. Meeker, and D.M. Swineford. 1980. White-faced Ibis populations and pollutants in Texas, 1969-1976. Southwest Nat. 25:225-239.

Kingery, H.E. 1980. Mountain west. Am. Birds 34:184-187.

Kingery, H.E. 1988. Mountain west. Am. Birds 42:1321-1324.

Knopf, F.L. 1979. Spatial and temporal aspects of colonial nesting of White Pelican. Condor 31:353-363.

Kotter, B.L. 1970. An ecological natural history of the White-faced Ibis (*Plegadis chihi*) in northern Utah. M.S. Thesis, University of Utah, Salt Lake City.

Lack, D. 1947. The significance of clutch-size, I-II. Ibis 89:302-352.

Lack, D. 1948. The significance of clutch-size, III. Ibis 90:25-45.

Lack, D. 1954. The natural regulation of animal numbers. Methuen Books, Oxford, England.

Lopinot, A.C. 1951. Raccoon predation on the Great Blue Heron, *Ardea herodias*. Auk 68:235.

Lowery, G.H. 1974. Louisiana Birds, 3rd ed., Louisiana State University Press, Baton Rouge, Louisiana.

Martin T.E. 1988. Processes organizing open-nesting bird assemblages: competition or nest predation? Evol. Ecol. 2:37-50.

Mayfield, H.F. 1961. Nesting success calculated from exposure. Wilson Bull. 73:255-261.

Mayfield, H.F. 1975. Suggestions for calculating nest success. Wilson Bull. 87:456-466.

Meanley, B. 1955. A nesting study of the Little Blue Heron in eastern Arkansas. Wilson Bull. 67:84-99.

Milstein, P., I. Prestt, and A.A. Bell. 1970. The breeding cycle of the Grey Heron. Ardea 58:171-255.

Mock, D.W., and G.A. Parker. 1986. Advantages and disadvantages of egret and heron brood reduction. Evolution 40:459-470.

Nisbet, I.C.T. 1973. Courtship-feeding, egg size and breeding success in Common Tern. Nature 241:141-142.

Palmer, R.S., ed. 1962. Handbook of North American birds, vol. 1. Yale University. Press, New Haven, CT. 1:177-178.

Parnell J.F., and M.A. Shields. 1990. Management of North Carolina's colonial waterbirds. UNC Sea Grant Publication Number UNC-SG-90-03, University Graphics, University of North Carolina.

Patterson, I.J. 1965. Timing and spacing of broods in the Black-headed Gull *Larus ridibundus*. Ibis 107:433-459.

Ricklefs, R.E. 1969. An analysis of nesting mortality in birds. Smithsonian Contributions to Zoology 9:1-48.

Rodgers, J.A., Jr. 1987. On the antipredator advantages of coloniality:a word of caution. Wilson Bull. 90:269-270.

Rodgers, J.A., Jr., and H.T. Smith. 1991. Minimum buffer zone requirements to protect nesting bird colonies from human disturbance. Florida Fish and Game Comm. Rept.

Ryder, R.A. 1967. Distribution, migration and mortality of the White-faced Ibis (*Plegadis chihi*) in North America. Birdbanding 38:257-277.

Ryder, R.A., W.D. Graul, and G.C. Miller. 1979. Status, distribution and movements of Ciconiiformes in Colorado. Proc. Colonial Waterbird Group 3:49-57.

Ryder, R.A., and D.E. Manry, 1994. White-faced Ibis (*Plegadis chihi*). *In* The Birds of North America, No. 130 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Ryder, R.L., and J.P. Ryder. 1981. Reproductive performance of Ring-billed Gulls in relation to nest location. Condor 83:57-60.

SAS Institute, Inc. 1990. SAS/STAT user's guide, 1990. ed. SAS Inst. Inc., Cary, NC.

Schreur, J.L. 1987. Ciconiiform reproductive success and public viewing in the San Luis Valley, Colorado. M.S. Thesis, Colorado State University, Fort Collins.

Sharp, B.S. 1985. White-faced Ibis management guidelines Great Basin population. U.S. Fish and Wildlife Service, Portland, OR. In Ryder, 1990.

Southern, L.K., and W.E. Southern. 1979. Absence of nocturnal predator defense mechanisms in breeding gulls. Colonial Waterbirds 2:91-101.

Southern, W.E., S.R. Patton, L.K. Southern, and L.A. Hanners. 1985. Effects of nine years of fox predation on two species of breeding gulls. Auk 102:827-833.

Steele, B.B. 1980. Reproductive success of the White-faced Ibis: effects of pesticides and colony characteristics. M.S. Thesis, Utah State University, Logan.

Steele, B.B. 1984. Effects of pesticides on reproductive success of White-faced Ibis in Utah, 1979. Colonial Waterbirds 7:80-87.

Stott, K., Jr. 1948. Notes on the longevity of captive birds. Auk 65:402-405.

Tenaza, R. 1971. Behavior and nesting success relative to nest location in Adelie Penguins *Pygoscelis adeliae*. Condor 73:81-92.

Tremblay, J., and L.N. Ellison. 1979. Effects of human disturbance on breeding of Black-crowned Night-Herons. Auk 96:364-369.

Wolford, J.W., and D.A. Boag. 1971. Distribution and biology of Black-crowned Night-Herons in Alberta. Canada. Field-Natur. 85:13-19.

CHAPTER IV

NESTLING GROWTH AND DEVELOPMENT IN THE WHITE-FACED IBIS IN LACASSINE NATIONAL WILDLIFE REFUGE, SOUTHWESTERN LOUISIANA

INTRODUCTION

Measurements of birds serve several purposes: (1) determining differences between species and subspecies; (2) determining family characteristics; and (3) learning variations within a species (Baldwin *et al.* 1931). Studies requiring nestling age estimates to determine food resource availability or to monitor the extent of contaminants in the estuarine environment (Custer and Peterson 1991) may also benefit from baseline growth data.

Little information is available on growth rates of the White-faced Ibis (*Plegadis chihi*). Kaneko (1972) collected hatchling growth data in Utah, but no studies have been performed in Louisiana or other Gulf Coast states to determine nestling growth.

Other Ciconiiformes, primarily herons and egrets, have been the subjects of more extensive studies of chick development. Most results have been expressed as the average of entire broods rather than the growth of individual chicks according to their hatching order within broods (McClure *et al.* 1959, McVaugh 1972, 1976). Growth measurements of individual Great Egrets (*Casmerodius*

albus) and Black-crowned Night-Heron (*Nycticorax nycticorax*) chicks were significantly different as a result of hatching order (Custer and Peterson 1991).

My primary objectives in this phase of my study were to measure the exposed culmen, forearm, tarsometatarsus ("tarsus"), and mass of White-faced Ibis nestlings, and analyze and compare these data to calculate average growth and determine if hatching order, brood size, and nesting year affected chick growth.

A secondary objective was to determine food items consumed by White-faced Ibis nestlings. Questions have been raised about the detrimental impact wading birds, including White-faced Ibises, may have on crawfish (*Procambarus clarkii*) farming in Louisiana's coastal region (Huner 1990, 1993). The concern is serious enough to prompt an article in a publication of the Louisiana Crawfish Farmers' Association that laments the fact that it "is difficult to obtain permits to kill them" (Huner 1990).

Few studies have been conducted on food consumption in Ciconiiformes (Palmer 1962), including the White-faced Ibis. Because we know little about the food requirements of White-faced Ibis nestlings, I opportunistically collected regurgitated pellets and analyzed their contents.

Measurements and food samples were taken of hatchlings in the black willow (*Salix nigra*) site in Lacassine National Wildlife Refuge, Louisiana (Fig. 4.1).

METHODS

GENERAL

I took repeated measurements from a total of 92 chicks in 84 nests in 1994 and 1995. Each year I measured exposed culmen length, forearm length, and mass, and I measured tarsus length through all of 1994 but only part of 1995. In 1994 I took 261 measurements for each parameter from 57 chicks in 50 nests. In 1995 I recorded 123 measurements for each parameter on 35 chicks in 34 nests.

STUDY SITE

In early June 1994, I divided the 2,700-m site into 90 sections of 30 m. A total of 50 nests were chosen from four randomly selected sections (22, 33, 66, 69) (Fig. 4.2) and the nests and sections were marked with numbered flagging tape.

In March 1995, I divided the same site into 27 sections of 100 m, and I randomly selected one section (section 12) from which to collect chick growth data (Fig. 4.3). To minimize human disturbance of nesting ibises, we waited until 21 June, late in the incubation phase, to mark and number 40 nests. Five days after our initial visit we found that massive predation had

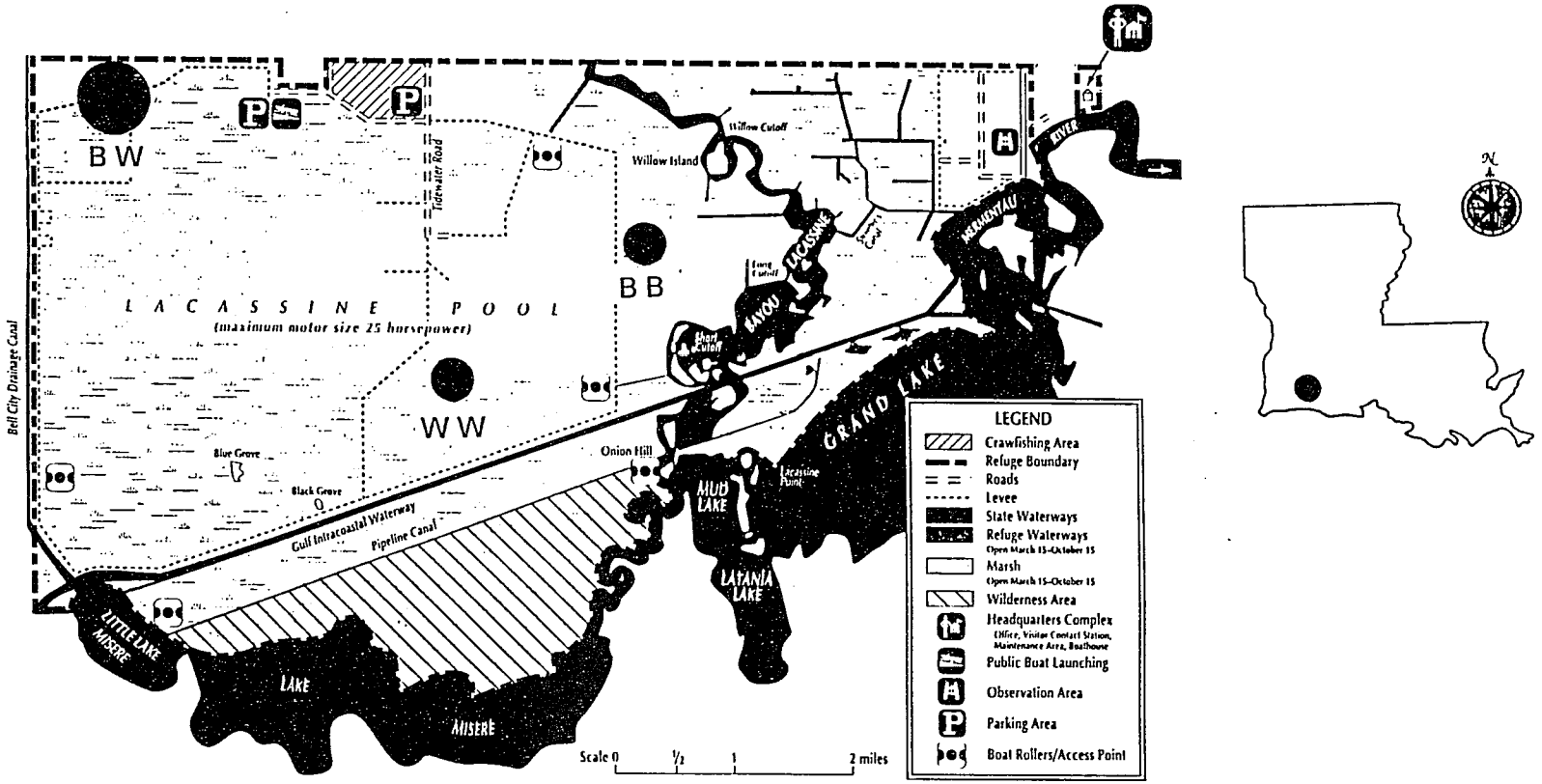


Figure 4.1. Major nesting sites of White-faced Ibises in Lacassine National Wildlife Refuge, Louisiana, 1995 (BW = black willow colony; BB = buttonbush colony; WW = water willow colony).

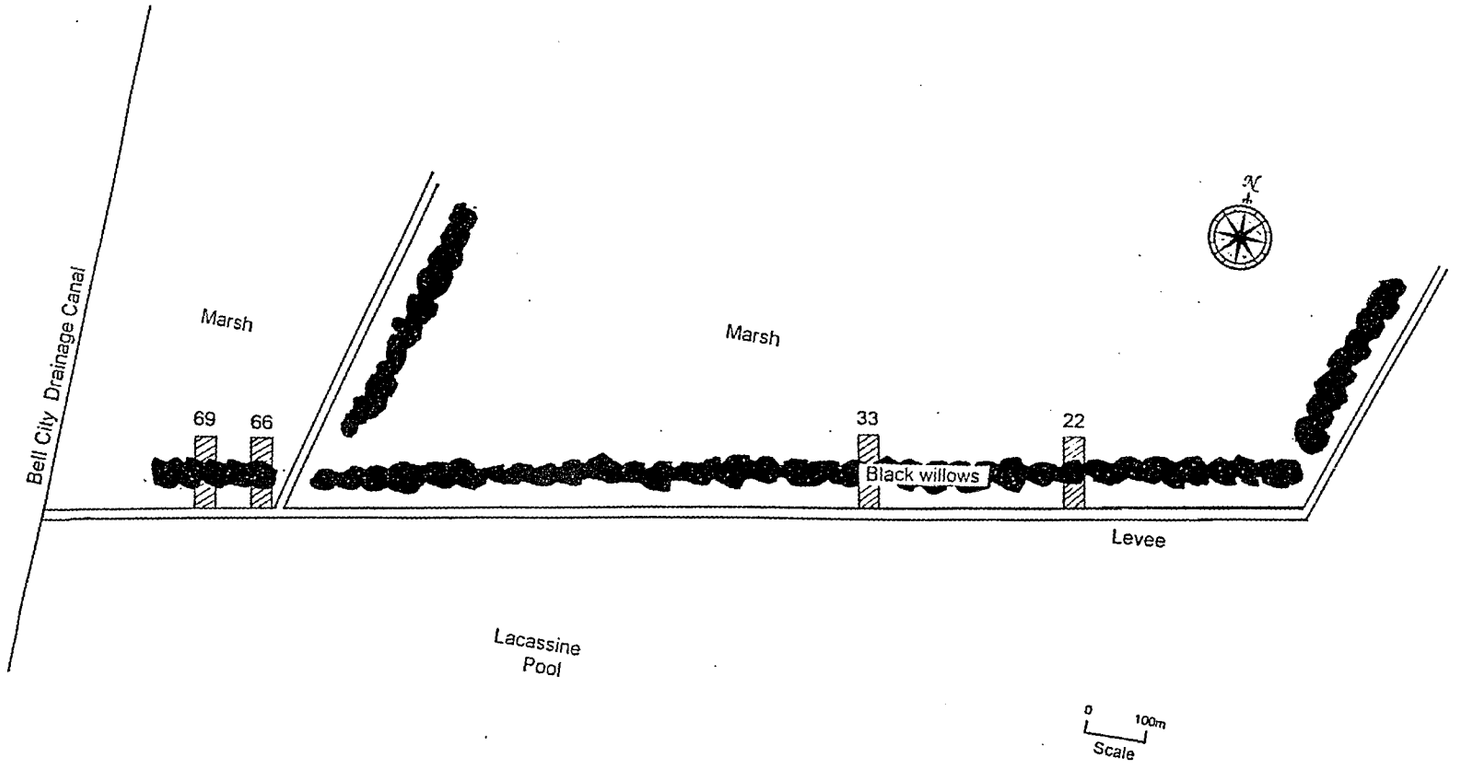


Figure 4.2. Study sections in the black willow site, Lacassine National Wildlife Refuge, Louisiana, 1994.

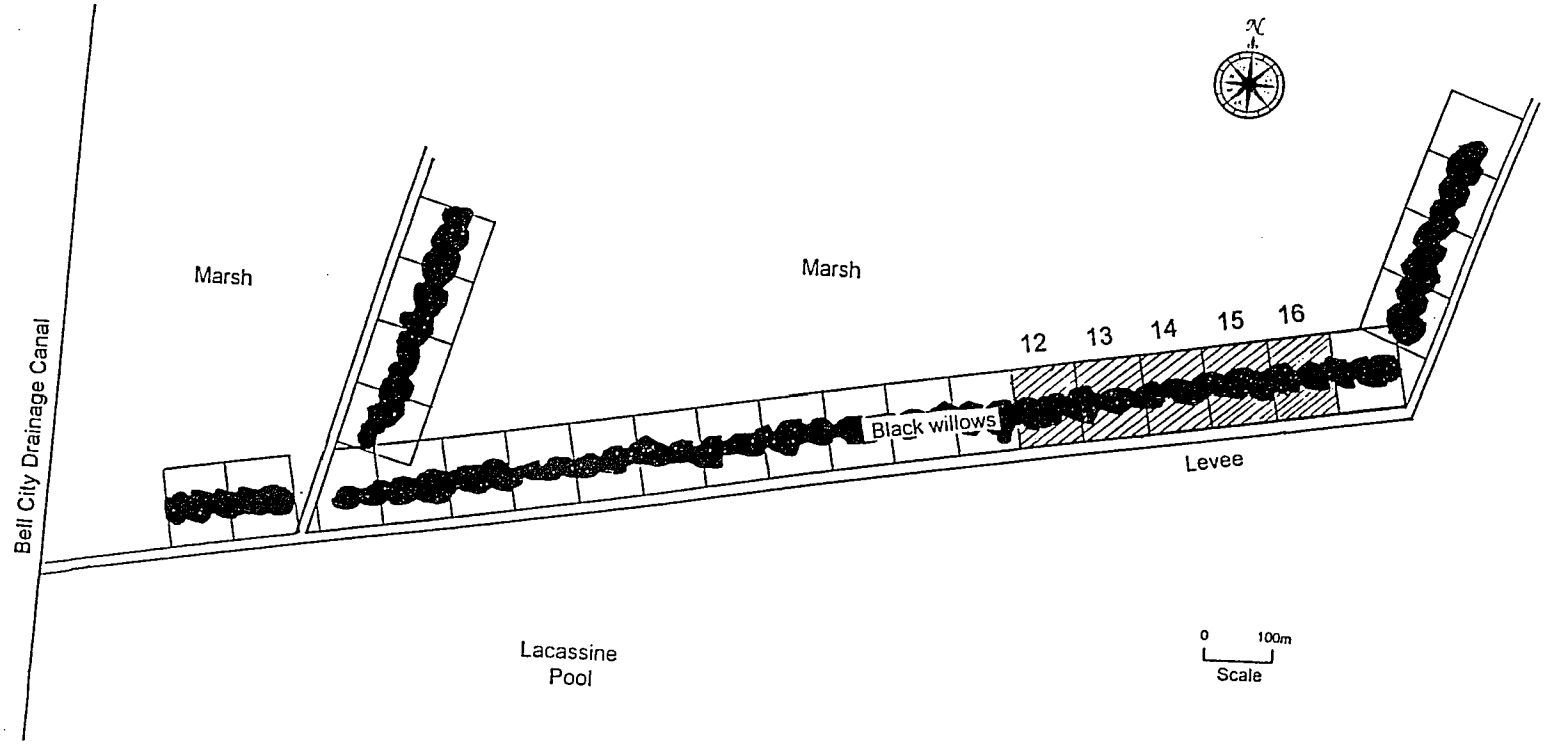


Figure 4.3. Study sections in the black willow site, Lacassine National Wildlife Refuge, Louisiana, 1995.

occurred, and all but two nests were destroyed. As a result, because we were unable to continue our study in section 12, we improvised by selecting 34 nests in sections 13 through 16, the only sections with a sufficient number of active nests. These new nests were marked and numbered with white surveyor's flagging to distinguish them from nests used in a concurrent reproductive study (Chapter III).

FIELD PROCEDURES - CHICK GROWTH AND DEVELOPMENT

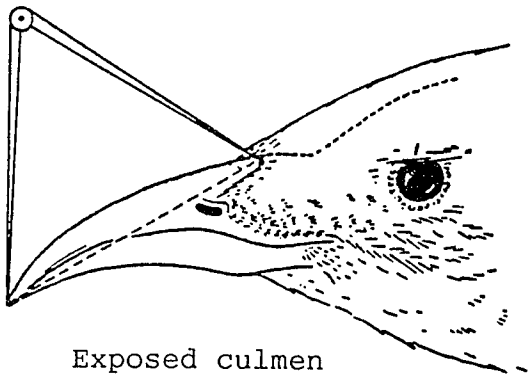
In order to determine hatch dates, we selected nests with only eggs, and no chicks. Nests were also selected for their accessibility so that chicks could be easily and quickly captured and measured. We reached nests by climbing trees or standing on a 3-m ladder. In this manner we could access nests under 4.8 m in height. To obtain the largest possible sample, we did not limit clutch size in selecting nests.

Day of hatch (day 0) was determined by direct observation or by estimations (agreed upon by two observers) based on several characteristics. Chicks were estimated to have hatched on the day observed if they were: (1) partly in their eggs; (2) covered with remnants of yolk or eggshell (or if remnants were in their nest); (3) damp or wet; (4) in a curled egg-shape position; or (5) in an advanced piping stage (indicating they would hatch later that day, following our departure) - or if

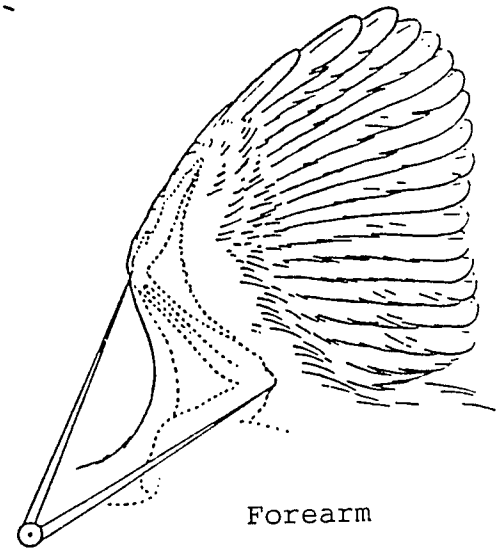
they had: (6) bare skin on face, legs, feet, and abdomen; (7) pink skin and feet; (8) a reddish pink bald spot on crown. I had previously observed all these characteristics, and other researchers have also observed characteristics 3, 6, 7, and 8 in earlier studies of the White-faced Ibis (Belknap 1957, Kotter 1970, Kaneko 1972).

We marked the toenails of nestlings with different colored nail polish according to hatching order within each nest. When the chicks were large enough, we temporarily used numbered plastic bands for identification. The bands were removed shortly before the chicks became large enough to avoid capture.

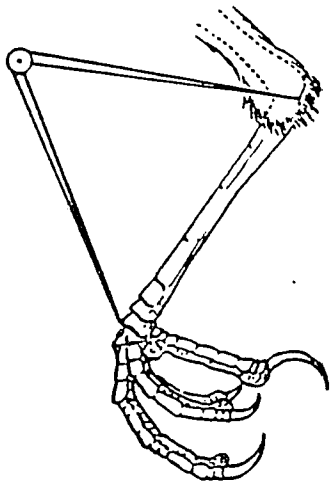
After chicks hatched, we took four repeated measurements on alternate days. These were: (1) exposed culmen length (mm); distance from the tip of the maxilla to the point where the tips of the forehead feathers impinge upon the culmen; (2) forearm length (mm); (3) tarsometatarsus length (mm); and (4) body mass (g) determined to the nearest 2 g for nestlings weighing less than 200 g, and to the nearest 10 g for chicks weighing more than 200 g. The measurement methods conformed to Baldwin *et al.* (1931) (Fig. 4.4). Lengths were measured with Vernier type 6914 calipers, and body mass was determined by weighing chicks in a 30 x 45-cm nylon mesh bag with Homs spring scales (200 g x 2 g and 1 kg x 10 g). We recorded measurements on daily field forms and later



Exposed culmen



Forearm



Tarsometatarsus

Figure 4.4. Anatomy measurements (Baldwin *et al.* 1931).

transferred them to cumulative growth forms for individual chicks. In addition to chick mass and growth data, we also recorded chick band numbers and nest status (nest condition and number of eggs or chicks), and noted causes of nest, egg, and chick failure, presence of predators, etc.

To maintain consistency of measurements and reduce chick stress I alone (except for a brief period) handled and measured nestlings. When necessary, I used a crab net to assure the safe capture of large chicks. The nestlings were measured at approximately the same time each day (7:30 a.m. to 12:00 p.m.), unless we were delayed by rain. To limit human impact, we wore similar clothes each day and worked as quickly and quietly as possible.

Chicks were measured until they disappeared, died, or were no longer accessible (at which time they were monitored until they were indistinguishable from other congregating chicks).

FIELD PROCEDURES - FOOD SAMPLING

An analysis of food habits was made from undigested food regurgitated by nestlings. I recovered regurgitated pellets whenever the opportunity presented itself--four times in all. The pellets were frozen and later analyzed by Vicky Moseley, Curator, Louisiana State Anthropod Museum.

DATA ANALYSIS

Hatching asynchrony was measured as the number of days between hatching dates. The first chick hatched in each nest was designated an "A" chick, the second designated "B," etc. On two occasions, when chicks hatched on the same day and I could not determine hatching order, I classified the larger sibling as the "A" chick.

Size comparisons were made among A-, B-, and C-chicks.

Brood sizes changed as chicks were lost, so I was unable to assess how growth rates were influenced by brood sizes that remained constant. As an alternative, I compared A-chick growth in nests with initial brood sizes of one, two, and three, and B-chick growth in nests with initial brood sizes of two and three.

Comparisons were made between chicks surviving 14 days or more ("fledging") and nonsurviving chicks.

Also, yearly comparisons were made between A-, B-, and C-chicks.

Comparisons of chick sizes with adult sizes and with chick sizes in Utah are based on measurements taken in 1994. Growth data from both years were not combined because there were slight but statistically significant differences between the years. Measurements from 1994 were used because more chicks were measured in 1994,

chicks survived longer, and their tarsus measurements were recorded throughout the entire season.

Average adult culmen and tarsus sizes were determined by measuring 10 male and 10 female specimens in the Museum of Natural Science, Louisiana State University. Most of these had been collected in southern Louisiana, primarily from Cameron Parish, where Lacassine National Wildlife Refuge is located. Adult mass (in breeding season) was obtained from 32 males and 35 females (Dunning 1984).

Statistical analyses were performed using the Statistical Analysis System (SAS) available through Louisiana State University's Computing Services Center (SAS Institute, Inc. 1990). I used ANOVA models to compare growth: (1) by hatching order; (2) of A-chicks according to brood size; (3) of fledging and nonsurviving chicks; and (4) by year. Comparisons were made on hatch day and on days 5, 10, and 15. To increase sample size, data were interpolated on days 5, 10, and 15. A Fisher's protected least squares difference (LSD) test was used to compare means that were significantly different. The level of significance was Alpha = 0.05.

RESULTS

GENERAL

Twenty-eight of the 50 nests selected for growth analysis in 1994 failed during the incubation stage. The remaining 22 nests produced 57 chicks, 19 of which

survived at least 14 days. The two longest-surviving chicks that we were able to capture and measure were 20 days old. The most common brood size was three (N = 12 nests). The other brood sizes were two (N = 7), one (N = 2), and five (N = 1).

Fifteen of the 34 nests failed during the incubation stage in 1995. The remaining nests produced 35 chicks, 5 of which survived through 14 days. Broods of two were most common (N = 12 broods). Other brood sizes were one (N = 5) and three (N = 2).

HATCHING ASYNCHRONY

Hatching intervals were variable for both years (Table 4.1). In 1994 most B-chicks hatched 1 day after A-chicks (N = 11 chicks, 58%), and most C-chicks hatched 2 days after B-chicks (N = 6, 43%). Only one brood included D- and E-chicks. Both hatched on the same day, 7 days after the A-chick hatched.

Lengths of time between hatching intervals may have had some impact on survival. The three surviving B-chicks hatched 1 day after the A-chick hatched. Nonsurviving B-chicks hatched an average of 1.3 days after A-chicks. Similarly, surviving C-chicks hatched 2 days after A-chicks, a shorter period than nonsurviving C-chicks which hatched 2.2 days after A-chicks. One surviving C-chick hatched on the same day as the B-chick.

Table 4.1. Days between hatching of White-faced Ibis chicks, Lacassine National Wildlife Refuge, Louisiana, 1994 and 1995.

		Chick Hatching Order			
	Days	A–B	B–C	C–D	D–E
		---------Number of Chicks Examined--------			
1994	0	3	1		1
	1	11	2		
	2	2	6		
	3	3	4		
	4		1	1	
	Mean	**1.3 (N = 19)**	**2.1 (N = 14)**	**4 (N = 1)**	**0 (N = 1)**
1995	0	4			
	1	4	1		
	2	3	1		
	3				
	4	1			
	5	1			
	6				
	7	1			
	Mean	**1.9 (N = 14)**	**1.5 (N = 2)**		

In 1995 most B-chicks hatched on either the same day as A-chicks (N = 4 chicks) or 1 day later (N = 4). The longest hatching interval between A- and B-chicks was 7 days.

GROWTH - COMPARISON BY HATCHING ORDER

1994

Comparisons of chick sizes by hatching order were made on hatch day and on days 5, 10, and 15 (Table 4.2). There were statistically significant differences in tarsus size between A- (18.6 ± 0.9 mm) and C-chicks (17.0 ± 0.0 mm) on hatch day ($T = 2.36$, $df = 7$, $P = 0.0436$) and again between A- (36.5 ± 5.5 mm) and C-chicks (29.1 ± 4.6 mm) on day 5 ($T = 2.03$, $df = 33$, $P = 0.0062$), but these differences were no longer significant by day 10. Significant differences also occurred on day 5 between forearm lengths ($F = 4.34$, $df = 33$, $P = 0.0212$) of A-chicks (37.8 ± 5.2 mm) and C-chicks (31.4 ± 5.4 mm) and mass ($T = 2.03$, $df = 33$, $P = 0.0076$) of A-chicks (138.7 ± 35.2 g) and C-chicks (88.7 ± 36.3 g). However, by day 10 these differences were no longer significant.

In one nest, the B-chick stopped growing after 7 days. Its weight on days 7, 9, and 11 was 88, 84, and 86 g respectively. The A-chick, although only 1 day older, had significant weight gains; it weighed 130, 260, and 340 g on those same days.

Table 4.2. Comparison of White-faced Ibis chick sizes by hatching order (A, B, C), Lacassine National Wildlife Refuge, Louisiana, 1994 and 1995. Data presented are means (± 1 SE) with sample size in parentheses. Analyses of variance (ANOVA) models were significant at the Alpha = 0.05 level.

Part measured		Day 0	Day 5	Day 10	Day 15
CULMEN					
1994	A	13.2 ± 0.5(5)	24.3 ± 3.1(19)	36.5 ± 3.1(16)	46.8 ± 1.8(8)
	B	14.0 ± 0.0(2)	23.8 ± 1.8(10)	34.7 ± 4.9 (6)	47.0 ± 2.8(2)
	C	13.7 ± 0.6(3)	22.1 ± 2.0 (7)	35.0 ± 2.0 (3)	ND
1995	A	14.1 ± 0.7(7)	24.5 ± 2.1(14)	38.0 ± 3.4 (6)	45.0 ± 2.0(3)
	B	13.5 ± 0.8(8)	23.6 ± 3.2 (5)	ND	ND
	C	ND*			
FOREARM					
1994	A	18.0 ± 0.7(5)	37.8 ± 5.2(19)[A]	65.7 ± 6.4(16)[A]	90.5 ± 3.5(8)
	B	18.5 ± 0.7(2)	35.8 ± 3.8(10)	57.7 ± 12.2 (6)[B]	88.0 ± 2.8(2)
	C	17.3 ± 0.6(3)	31.4 ± 5.4 (7)[B]	61.0 ± 2.0 (3)	ND
1995	A	19.0 ± 1.2(7)	42.6 ± 4.1(14)	69.5 ± 5.3 (6)	90.3 ± 5.8(3)
	B	20.3 ± 1.0(8)	40.8 ± 4.0 (5)	ND	ND
	C	ND			

(table con'd.)

Part measured		Day 0	Day 5	Day 10	Day 15
TARSUS					
1994	A	18.6 ± 0.9(5)[A]	36.5 ± 5.5(19)[A]	57.4 ± 4.2(16)	74.1 ± 4.3(8)
	B	18.5 ± 0.7(2)	33.7 ± 3.2(10)	53.0 ± 10.1 (6)	72.5 ± 3.5(2)
	C	17.0 ± 0.0(3)[B]	29.1 ± 4.6 (7)[B]	52.0 ± 0.0 (3)	ND
1995	A	ND			
	B	ND			
	C	ND			
MASS					
1994	A	25.6 ± 10.4(5)	138.7 ± 35.2(19)[A]	282.8 ± 35.9(16)	373.1 ± 41.0(8)
	B	27.0 ± 1.4(2)	120.0 ± 28.6(10)	238.3 ± 81.5 (6)	367.0 ± 24.8(2)
	C	22.0 ± 2.0(3)	88.7 ± 36.3 (7)[B]	235.0 ± 5.0 (3)	ND
1995	A	28.1 ± 6.4(7)	147.3 ± 28.4(14)	312.7 ± 44.8 (6)	342.3 ± 30.7(3)
	B	27.1 ± 5.5(8)	147.4 ± 35.8 (4)	ND	ND
	C	ND			

* ND = No data

A,B = Differences were statistically significant

Survival rates were distinctly different for first, second, and third hatched chicks. In 1994, 14 of 19 A-chicks (74%), 3 of 19 B-chicks (16%), and 2 of 19 C-chicks (11%) survived at least 14 days (Fig. 4.5).

1995

There were no significant differences between chick measurements of A-, B-, and C-chicks in 1995. But, as in 1994, survival was related to hatching order. Five of 19 A-chicks fledged, but none of the 14 B-chicks or 2 C-chicks survived.

GROWTH - COMPARISON BY BROOD SIZE

1994

There were no statistically significant differences for any measurement on hatch day, day 5, 10, or 15 among A-chicks in broods of one, two, or three chicks; or between B-chicks in broods of two and three chicks. Measurements of A-chicks in broods of one were not available for hatch day and day 15.

1995

As in 1994, sizes of A-chicks in broods of one, two, or three chicks, and B-chicks in broods of two or three chicks were similar on each day they were compared.

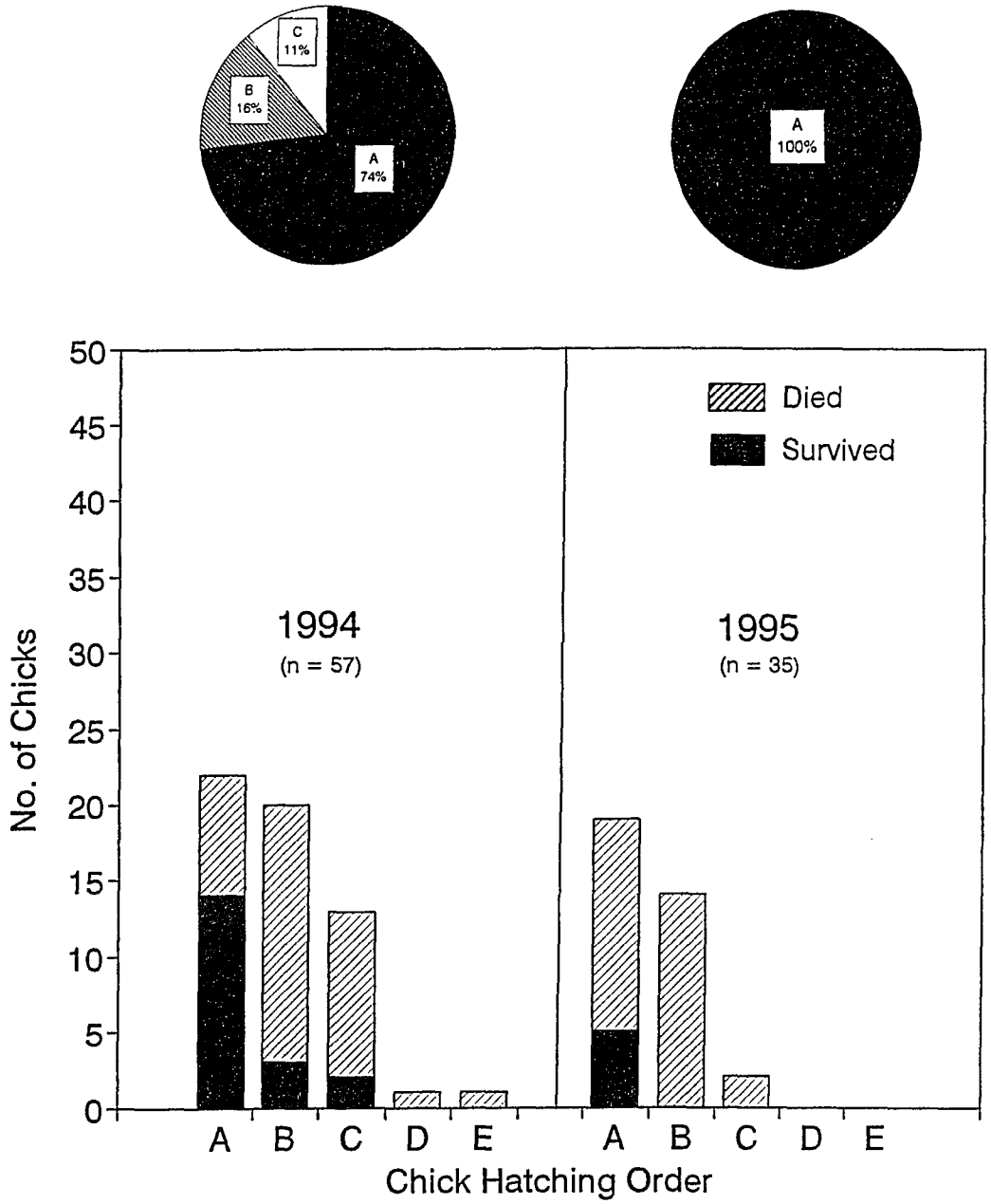


Figure 4.5. Number of fledging White-faced Ibis chicks (by hatching order) in the black willow colony, Lacassine National Wildlife Refuge, Louisiana, 1994 and 1995. Pie charts denote percentages of total surviving young made up by each hatching order group.

GROWTH - COMPARISON BY SURVIVAL

1994

There were no significant differences in measurements between A-chicks that lived at least 14 days (fledged) and those that did not fledge.

1995

No significant differences were found between fledging and nonsurviving chicks.

GROWTH - COMPARISON BETWEEN YEARS

Chicks in 1995 had three significantly larger measurements than those in 1994. A-chicks in 1995 had a longer culmen on hatch day (14.14 $\pm$ 0.69 mm vs. 13.20 $\pm$ 0.45 mm) than A-chicks in 1994 ($T = 2.23$, $df = 10$, $P = 0.0238$) and a longer forearm on day 5 (42.57 $\pm$ 4.05 mm vs. 37.79 $\pm$ 5.17 mm) than A-chicks in 1994 ($T = 2.04$, $df = 31$, $P = 0.0074$). On day 5, 1995 B-chicks had a longer forearm (40.8 $\pm$ 5.13 mm) than 1994 B-chicks (35.8 $\pm$ 2.94 mm) ($T = 2.16$, $df = 13$, $P = 0.0345$). No significant differences remained by day 10.

GROWTH - COMPARISON BETWEEN CHICK AND ADULT SIZES

Sigmoidal growth patterns for mass and forearm and tarsus lengths were similar to those of most birds (O'Connor 1984). Growth of each measured parameter followed a sigmoidal (S-shaped) growth curve. Initially small size increases through day 2 were followed by rapid

growth through day 15, at which time growth slowed as chicks approached asymptotic, or adult, sizes.

The tarsus developed the most rapidly, attaining 78% of adult male length and 96% of adult female length by day 20 (Table 4.3).

Average mass was 57% of adult male and 71% of adult female mass by day 20.

Culmens grew the slowest, reaching only 39% of adult male size and 52% of adult female size by day 20.

Forearms grew on average from 18 mm on hatch day to 91 mm on day 15 and 105 mm by day 20. Growth followed a pattern similar to those of other parameters, but I was unable to obtain adult sizes for comparison.

GROWTH - COMPARISON BETWEEN LOUISIANA AND UTAH CHICKS

I compared sizes of chicks in my study in 1994 (Louisiana chicks) with White-faced Ibis chicks in a colony at Utah Lake, near Provo, Utah (Kaneko 1972) (Table 4.4). On average, the culmen of the Utah chicks was longer on hatch day, but by day 20 it was longer in Louisiana chicks (54.5 vs. 50.2 mm). In Utah, culmen length was measured from the tip of the maxilla to the corner of the mouth ("gape culmen"). I measured from the tip of the maxilla to feathers of the forehead ("exposed culmen"). "Gape culmen" measurements are slightly greater than "exposed culmen" measurements (Baldwin *et al.* 1931).

Table 4.3. Measurement comparisons between chicks at Lacassine National Wildlife Refuge in 1994 and adult White-faced Ibises. Comparisons are expressed as the percentage of adult size attained by chicks. Numbers in parentheses are average adult sizes.

Part Measured	Days After Hatching: Day 0 (N = 10)	Day 5 (N = 14)	Day 10 (N = 17)	Day 15 (N = 3)	Day 20 (N = 2)
Exposed culmen length(mm)[1]					
Male (139.5)	0.10	0.17	0.26	0.34	0.39
Female (105.7)	0.13	0.22	0.34	0.44	0.52
Tarsus length(mm)[1]					
Male (106.0)	0.17	0.32	0.53	0.70	0.78
Female (86.4)	0.21	0.40	0.64	0.85	0.96
Mass(g)[2]					
Male (679)	0.04	0.18	0.39	0.55	0.57
Female (546)	0.05	0.23	0.49	0.68	0.71

[1] Lengths from Museum of Natural Science, Louisiana State University; N = 10 adult males; 10 adult females.

[2] From Dunning (1984), in breeding season; N = 32 adult males; 35 adult females.

Table 4.4. Comparisons of mean value of variables between White-faced Ibis chicks in Utah (1970, 1971)[1] and Lacassine National Wildlife Refuge, Louisiana (1994). Numbers in parentheses are sample sizes.

Variable Measured	Days After Hatching				
	Day 0	Day 5	Day 10	Day 15	Day 20
Culmen (mm)[2]					
Utah	15.2 (9)	26.0(18)	37.2(19)	45.4(7)	50.2(2)
La.	13.5(10)	23.3(14)	36.0(17)	46.7(3)	54.5(2)
Tarsus (mm)					
Utah	16.0 (9)	29.5(17)	49.5(19)	67.0(5)	69.8(2)
La.	18.1(10)	33.5(14)	56.6(17)	71.7(3)	83.0(2)
Mass (g)					
Utah	28.0(12)	140.0(22)	270.0(20)	400.0(5)	360.0(2)
La.	24.8(10)	123.9(14)	278.6(17)	363.3(3)	385.0(2)

[1] Measurements are estimated from a graphic presentation (Kaneko 1972).

[2] Utah measurement is length of bill from tip of maxilla to corner of mouth (gape culmen). Louisiana measurement is length of bill from tip of maxilla to feathers of the forehead (exposed culmen). Gape culmen measurements are slightly greater than exposed culmen measurements (Baldwin *et al.* 1931).

Average hatching mass of Utah chicks (28 g) was slightly greater than that of Louisiana chicks (24.8 g), but on day 20, Utah chicks (360 g) weighed only 94% of what chicks in Louisiana weighed (385 g).

The average tarsus length of Louisiana chicks exceeded that of Utah chicks on hatch day, and though this initial difference lessened, it persisted with time. Length of tarsus on day 20 in Utah chicks (69.8 mm) was 84% of that of Louisiana chicks (83 mm).

FOOD ITEMS

Food items, percentages of total volume, and frequency (total number of food items found) in each regurgitated chick pellet are listed in Table 4.5.

Beetles (Coleoptera) were the only item found in every pellet. Each pellet consisted of one or two primary foods. For example, 70% of pellet 1 consisted of aquatic bugs (*Belostoma* sp.) and 91% of pellet 3 consisted of horsefly larvae (Diptera). Beetles (47%) and dragonfly larvae (Odonata) (40%) were the two primary items found in pellet 2. Pellet 4 comprised mostly non-food plant material (88%) with few food items.

No pellets contained crawfish, nor were any crawfish remnants found in or around nests in either year.

On one occasion, immediately after being weighed, a 10-day-old chick regurgitated a pellet that contained live

Table 4.5. Percentages (by volume) of food items found in regurgitated pellets of four nestling White-faced Ibises, Lacassine National Wildlife Refuge, Louisiana, 1995. Numbers in parentheses are frequency of food items.

	Pellet Number			
Food Item	1	2	3	4
Coleoptera (larvae & adults)				
Hydrophilidae	15.0(2)	47.0(3)	1.0(1)	8.0(11)
Diptera (larvae)			91.0(18)	2.0(2)
Hemiptera				
Belostomatidae *Belostoma* sp.	70.0(5)			2.0(1)
Odonata (larvae)		40.0(2)		
Earthworms	5.0(1)	1.0(3)		
Mollusk shell		2.0(1)		
Plant material	10.0	10.0	8.0	88.0

beetle larvae. The chick weighed 325 g before regurgitating, and 310 g after--a 15 g difference.

DISCUSSION

HATCHING ASYNCHRONY

The asynchronous hatching observed in my study was typical of the White-faced Ibis (Belknap 1957, Kotter 1970, Kaneko 1972, Capen 1977). The longest period between hatching in a single brood was 8 days, in a nest that contained six eggs. Most hatching occurred within 1 or 2 days of the previous chick's hatching (Table 4.1), although in 1995 as many as 4, 5, and 7 days elapsed between the hatching of first and second chicks. This may indicate that B-eggs were lost to predators or other causes, and the eggs hatching after such a long interval were actually C-eggs.

Because surviving B- and C-chick hatching intervals were shorter than nonsurviving chicks, it seems that shorter hatching intervals probably improved the ability of B- and C-chicks to compete with older siblings for food.

The asynchronous hatching of the White-faced Ibis may have enabled some chicks to fledge in spite of the high predation rates in the colony by minimizing the total amount of time individual eggs and nestlings spent in the nest (Clark and Wilson 1981).

Lack (1968) theorized that asynchronous hatching evolved as a parental strategy for raising the largest number of young possible when food availability is unpredictable. Since B- and C-chicks were not initially provided with more resources to compensate for delayed hatching (A-chicks had only one significantly larger measurement on hatch day), these results are consistent with Lack's brood reduction theory.

GROWTH COMPARISONS

Because there were no significant differences in growth as a function of brood size or survival, and few differences as a result of hatching order or year, food resources and parental provisioning (collecting and delivering food to the nestlings) skills must have been adequate and similar in both years.

Because growth was similar regardless of brood size, it seems that adults were able to provide sufficient food for as many as three nestlings (the maximum number of fledglings I observed in one nest). As confirmed by the results of my reproductive study (Chapter III), predation (not a lack of food) was the major cause of most chick deaths (84% in 1994 and 90% in 1995).

Growth rates were very similar in both years. The few significant size differences were no longer significant after day 10. It seems, therefore, that if starvation occurred, it took place prior to day 10.

Although statistical comparisons indicate that adequate food was available to foraging adults and starvation was not a major cause of mortality in the colony, there was a wide range of sizes in individual chicks, and a few may have starved. In 1994, four C-chicks grew minimally and the only D-chick died from starvation or from being trampled by three larger siblings. The failure of younger siblings to grow reflects the competitive disadvantage of smaller chicks when soliciting food. The case in which the A-chick gained 210 g (130 to 340 g) in 4 days while the B-chick lost 2 g (88 to 86 g) is an example of an older sibling developing superior food-handling capabilities. Researchers studying Cattle Egrets (*Bubulcus ibis*) (Fujioka 1985), Little Egrets (*Egretta garzetta*) (Inoue 1985), and egrets and herons (Mock and Parker 1986) report similar findings.

In 1995 only one nestling (with no siblings) failed to grow. It is possible that this one nest was abandoned, the adults were killed, or the adults were incapable of providing enough food. In a study of Kittiwakes (*Rissa triadactyla*), Coulson and Porter (1985) found that starvation of chicks could be attributed to younger, inexperienced adults, less adept at foraging and feeding their young.

Growth rates are apparently balanced between a chick's need for rapid growth to avoid predation and an adult's need for slower chick growth to reduce feeding requirements (Lack 1968).

COMPARISONS OF LOUISIANA CHICKS, UTAH CHICKS, AND ADULTS

Louisiana chicks were larger than Utah chicks on day 20, suggesting that in Louisiana food may be more abundant or the milder weather may be more conducive to foraging. However, because average brood sizes in Utah were slightly larger, Utah chicks were required to share food resources with more siblings than those in Louisiana.

In both Louisiana and Utah, rapid chick growth (an indication of sufficient food), occurred during the first 2 weeks and slowed during the 3rd week. Also, in both studies the tarsus grew most rapidly (attaining 96% of adult female length in Louisiana chicks and 81% in Utah chicks by day 20), and the culmen had grown least rapidly (attaining 52% and 47%, respectively by day 20). Similar results were observed in studies of the White Ibis (Bildstein 1993, Kushlan 1977). Bildstein suggests that "different selective pressures are acting on different parts of the nestling's body." He theorizes that legs develop rapidly to increase a nestling's ability to move toward parents returning with food and away from predators. In contrast, slow culmen growth is an adaptation that enhances food transfer from adults to

young chicks and improves bill maneuverability when chicks first fledge (Bildstein 1993).

FOOD ITEMS

Food items found in nestlings' pellets were similar to those found in two studies of White-faced Ibis nestlings (Kaneko 1972, Capen 1977) and one study of adult and immature ibises (Peterson 1953, In Ryder, 1967) in Utah. With the exception of more earthworms found by Capen (1977), food items from the Coleoptera and Diptera families were the most common in samples I collected and those found in other studies.

Although there were few significant differences in average sizes, individual chicks exhibited a wide range of growth patterns. These individual differences could be a reflection of different growth rates of male and female nestlings, or may reflect a difference in food quantity and quality (Gill 1990). Although I analyzed samples from only four chicks, one food pellet was obviously nutritionally inferior to the other three. It contained only 12% food items compared with 90% (N = 2 pellets) and 92% in the other samples. This difference in food quality may be attributed to younger, less experienced, adults (Coulson and Porter 1985), and might in turn explain individual differences in growth.

White-faced Ibises are reputed to consume crawfish on crawfish farms in Louisiana (J. Huner pers. comm.).

However, although it is likely that some crawfish were still available during the nesting season and crawfish ponds were within 10 km of the colony, I found no evidence that White-faced Ibises consumed them. I found no crawfish in the chick pellets I collected nor were crawfish remnants seen in or around nests during the 2 years of my study. This may be an indication that adults (and consequently nestlings) may feed on organisms other than crawfish (e.g., aquatic insects, snails, etc.) when they are observed feeding near crawfish ponds. It would seem to be premature, therefore, to kill White-faced Ibises feeding around crawfish farms until further study is conducted.

LITERATURE CITED

Baldwin, S.P., H.C. Oberholser, and L.G. Worley. 1931. Measurements of birds. Scientific Publications of the Cleveland Museum of Natural History 2:1-165.

Belknap, H.W. 1957. Observations on the White-faced Ibis (*Plegadis chihi*) in Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge.

Bildstein, K.L. 1993. White Ibis: Wetland Wanderer. Smithsonian Institution Press, Washington D.C., and London.

Capen, D.E. 1977. The impact of pesticides on the White-faced Ibis. Ph.D. Dissertation, Utah State University, Logan.

Clark, A.B., and D.S. Wilson. 1981. Avian breeding adaptations: hatching asynchrony, brood reduction, and nest failure. Quart. Rev. Biol. 56:253-277.

Coulson, J.C., and J.M. Porter. 1985. Reproductive success of the Kittiwake *Rissa tridactyla*: the roles of clutch size, chick growth rates and parental quality. Ibis 127:450466.

Custer, T.W., and D.W. Peterson. 1991. Growth rates of Great Egret, Snowy Egret, and Black-crowned Night-Heron chicks. Colonial Waterbirds 14(1):46-50.

Dunning, J.B., Jr. 1984. Body weights of 686 species of North American Birds. W.Bird Banding Assoc. Monograph. No.1.

Fujioka, M. 1985. Sibling competition and siblicide in synchronously-hatched broods of the Cattle Egret *Bubulcus ibis*. Animal Behaviour 33:1228-1242.

Gill, F.B. 1990. Ornithology. W. H. Freeman and Company, New York, NY.

Huner, J.V. 1990. Wading bird in crawfish, a new problem? Crawfish tales (First quarter 1990).

Huner, J.V. 1993. The crawfish pond: Louisiana's autumn oasis for waterfowl. The aquaculture news (December, 1993).

Inoue, Y. 1985. The process of asynchronous hatching and sibling competition in the Little Egret *Egretta garzetta*. Colonial Waterbirds 8:1-12.

Kaneko, K.D. 1972. Nesting of the White-faced Ibis (*Plegadis chihi*) on Utah Lake. M.S. Thesis, Brigham Young University, Provo, Utah.

Kotter, B.L. 1970. An ecological natural history of the White-faced Ibis (*Plegadis chihi*) in northern Utah. M.S. Thesis, University of Utah, Salt Lake City.

Kushlan, J.A. 1977. Differential growth of body parts in the White Ibis. Auk 94:164-167.

Lack, D. 1968. Ecological adaptations for breeding in birds. Methuen, London.

McClure, H.E., M. Yoshii, T. Okada, and W.F. Schere. 1959. A method for determining age of nestling herons in Japan. Condor 61:30-37.

McVaugh, W., Jr. 1972. The development of four North American herons. Living Bird 11:155-173.

McVaugh, W., Jr. 1976. The development of four North American herons. II. Living Bird 15:163–183.

Mock, D.W., and G.A. Parker. 1986. Advantages and disadvantages of egret and heron brood reduction. Evolution 40:459–470.

O'Connor, R.J. 1984. The growth and development of birds. Wiley, New York.

Palmer, R.S., ed. 1962. Handbook of North American birds, vol. 1. Yale University Press, New Haven, CT. 1:177–178.

Peterson, W.M. 1953. A food habit study of the White-faced Glossy Ibis. Unpublished. In Ryder, 1967.

Ryder, R.A. 1967. Distribution, migration and mortality of the White-faced Ibis (*Plegadis chihi*) in North America. Birdbanding 38:257–277.

SAS Institute, Inc. 1990. SAS/STAT user's guide, 1990 ed. SAS Inst. Inc., Cary, NC. 1686 pp.

SUMMARY

COLONY-SITE CHARACTERISTICS

Lacassine National Wildlife Refuge provides diverse habitats for thousands of wintering and nesting waterbirds. In recent years White-faced Ibises (*Plegadis chihi*) have nesting there at two sites with distinctly different vegetation: black willows (*Salix nigra*) and buttonbush (*Cephalanthus occidentalis*). In 1995 they were also observed nesting in a third site consisting entirely of water willows (*Decodon verticillatus*).

The largest colonies of White-faced Ibises nested in the black willow site--a habitat unique to populations nesting in southwestern Louisiana. This was the first study of the breeding biology of ibises nesting in tall trees rather than in herbaceous marsh vegetation, small bushes, or on dry land. Heights of the black willows reached 12.8 m, and nest heights ranged from 0.9 to 7.5 m.

In 1995 I used the point-centered-quarter method of plotless plant sampling (Cottam *et al.* 1953, Cottam and Curtis 1956) to conduct a habitat analysis of the overstory vegetation in 42% of the black willow site. Black willows were the most abundant tree species (92%); there were approximately 576 per ha. Mean diameter at breast height (dbh) was 16 cm with a range of 0.8 to 27 cm, and the basal area averaged 10.7 m^2 per ha.

Buttonbush made up 5% of the overstory and averaged 40 trees per ha. The mean dbh was 2 cm, and the basal area was 0.05 m^2 per ha.

Tallowtrees (*Sapium sebiferum*) were the least abundant species (3%), averaging 27 trees per ha with a mean dbh of 12 cm and a basal area of 0.6 m^2 per ha.

I used a modified version of the Aldous Deer Browse Survey (Aldous 1944) to estimate understory abundance on 16 plot samples. The most abundant taxa were American cupscale (*Sacciolepsis striata*) (33%) and boneset (*Eupatorium perfoliatum*) (33%), with 12 other taxa interspersed throughout the site.

In 1994, 96% of the site was underwater during the nesting period, and water depth averaged 33 cm within the colony. In 1995, bases of trees in the colony-site were 41 cm above the water's surface.

CHRONOLOGY AND ABUNDANCE

In 1995 the first nesting ibises in Lacassine were observed on 8 May in the water willow colony, which was not only the most isolated and predator-free site, but also the only site over deep water. There were approximately 50 ibis nests, although we observed as many as 125 adults in the colony. Other nesters included Tricolored Heron (*Egretta tricolor*), Yellow-crowned Night-Heron (*Nycticorax violaceus*), and Great Blue Heron (*Ardea herodias*), each of which had two nests.

The buttonbush site was the second site where ibises nested. We observed 16 adults and two nests on 23 May. Prior to their nesting, the site supported 23 Great Egret (*Casmerodius albus*) nests and 9 Little Blue Heron nests (*Egretta caerulea*).

The black willow site was the last, but largest, nesting-site used by ibises. The nesting chronology (date of first nest) and peak number of nests of all colonial waterbirds nesting in the colony were: Yellow-crowned Night-Heron (14 April, N = 16 nests), Cattle Egret (*Bubulcus ibis*) (19 April, N = 1,057), Tricolored Heron (4 May, N = 5), Anhinga (*Anhinga anhinga*) (13 May and 18 July, N = 2), White-faced Ibis (23 May, N = 622), White Ibis (*Eudocimus albus*) (6 June, N = 20), Little Blue Heron (6 June, N = 1), and Black-crowned Night-Heron (*Nycticorax nycticorax*) (21 June, N = 4).

On 23 May 1995, we observed six pairs of White-faced Ibises building nests. The hatching period ranged from 19 June to 16 July, and peak hatching took place on 6 July. The peak number of White-faced Ibis nests was 622, compared with 1,292 nests in 1994. Ibis nests composed 36% of the colony, Cattle Egrets 61% (1,057 nests), and all other species 3% (50 nests).

Cattle Egrets began nesting 5 weeks before White-faced Ibises in 1995, and egret chicks were beginning to hatch while ibises were still breeding. Cattle Egrets may

have affected ibis reproductive success differently each year. In 1994 the large numbers of simultaneously nesting egrets may have deterred some ibises from nesting altogether or caused them to use inferior sites. In 1995, however, when extensive predation occurred throughout the colony, the presence of egrets may have benefited ibises, because egrets most likely absorbed some of the losses. Without them, it is possible that no ibis eggs or hatchlings would have survived.

REPRODUCTIVE SUCCESS

I assessed the reproductive success of 50 nests with 57 chicks in 1994 and 242 nests with 205 chicks in 1995. Clutch sizes ranged from one to six eggs with a mean of 2.8 eggs in 1994 when the most frequent clutch sizes were three (N = 30 clutches) and two (N = 13). Average clutch sizes in 1995 were 2.6 (N = 124, 1995A) and 2.3 (N = 118, 1995B). It is likely that more extensive predation in 1995 caused the difference in clutch sizes between years. Clutches were smaller than those in more northern states, providing further support for the theory that latitudinal differences affect clutch size (Lack 1947, 1948, 1954).

The asynchronous hatching observed was typical of the White-faced Ibis. Although hatching times varied, most occurred within 1 or 2 days of the previous chick's

hatching. The longest period between hatching in a single brood (of five chicks) was 8 days.

Hatching rates, based on the number of eggs available immediately preceding hatch, were high both years--90% in 1994 and 93% in 1995. This seems to confirm that pesticides (which can cause thin, cracking, and crushed eggs) were not significant factors in egg failures in this colony.

Hatching success, based on the number of original eggs, was 41% in 1994, 1% in 1995A, and 74% in 1995B. In both years most losses were the result of substantial predation.

The percentages of successful nests (those that had one or more fledglings) were 28% in 1994, 1% in 1995A, and 42% in 1995B.

In 1994, 19 chicks (33%) fledged (survived to 14 days), in 1995A, 25% (1 of 4 chicks) fledged, and in 1995B, 75 chicks fledged (37%). In both years mortality was highest in the first 3 days, and more than half occurred within the first 5 days. Rates declined until day 12, when they increased, perhaps as a result of chicks venturing from the protection of their nests and adults leaving them unattended for longer periods, making them more vulnerable to predation.

Hatching order was a major factor in chick survival; 64% of A-chicks and 15% of B- and C-chicks fledged in

1994, and of all surviving chicks, 74% were A-chicks. The D- and E-chick did not survive. In 1995, 26% of A-chicks fledged, but no B- or C-chicks survived.

Estimated colony-wide annual reproduction was 1,473 hatchlings (mean = 1.14/nest) and 491 fledglings from 1,292 nests (mean = 0.38/nest) in 1994. In 1995 approximately 393 chicks hatched (mean = 0.63/nest) and 149 chicks fledged from 622 nests (mean = 0.24/nest). These rates fell far below the average yearly success rates (1.9/fledglings per nesting pair) necessary to maintain a stable population (Ryder 1967).

The water level in and surrounding the colony was the major environmental difference between years. Deeper water coincided with higher nest success in 1994 (than in 1995), when more alligators were present throughout the colony. Although a threat to individual ibises, their presence in the colony was apparently positive, as they seemed to limit the number of mammalian predators in the colony.

The majority of nest failures resulted from predation (67% in 1994, 100% in 1995A, and 96% in 1995B). We saw numerous predators who can consume eggs, chicks, or both. Terrestrial species observed in the colony included mink (*Mustela vison*), fire ants (*Solenopsis* spp.), rat snakes (*Elaphe obsoleta*), cottonmouths (*Agkistrodan piscivorus*), and American alligators (*Alligator mississippiensis*).

Also, raccoons (*Procyon lotor*) were observed near the colony, and tracks and scat were observed in the colony. Aerial predators included Yellow- and Black-crowned Night-Herons (Boat-tailed Grackles (*Quiscalus major*), and a Great Horned Owl *(Bubo virginianus*). The primary difference in predator abundance between years was the presence of more alligators and fewer mammalian predators in 1994.

Minor causes of nest failure included collapsed and abandoned nests, unknown causes, infertile eggs, and perhaps starvation. Losses due to investigator disturbance seemed minimal.

There was no conclusive evidence of renesting, although clutches added in five late nests may have been renesting attempts.

Nest-site location within the colony affected nest success. All the successful nests (those with 14-day-old fledglings) were built in black willows; nests in buttonbush, elderberry (*Sambucus canadensis*), and tallowtrees were unsuccessful. Numbers of fledglings in 1995 were significantly greater in top (mean = 1.06/nest) and bottom (mean = 0.86/nest) nests. Middle nests had the least success (mean = 0.45/nest), probably because they suffered compounded losses from both aerial predators from above and terrestrial predators from below.

In contrast to results from other studies, edge nests (N = 60) were more successful than interior nests (N = 58). Fifty chicks fledged from edge nests (0.83 fledglings per nest) compared with 25 chicks from interior nests (0.43/nest).

The number of hatched and fledged chicks was significantly greater in over-water nests in 1994. Over-water nests (N = 26) fledged 47 of 57 chicks (1.8/nest) compared with 10 fledglings (0.42/nest) in 24 over-land nests. The overall probability of nest success (at least one egg resulting in a 14-day-old chick), calculated according to Mayfield (1961, 1975), was 0.25 for over-water nests and 0.06 for over-land nests.

The species of nearest nesting neighbors to ibis nests (Cattle Egret 66%, White-faced Ibis 33%, and other 1%) approximately mirrored the abundance of each species in my study nests. Nearest-neighbor species had no impact on chick survival, as 0.64 chicks fledged in ibis nests regardless of whether the nearest neighbor was an egret or a conspecific.

Distances from ibis nests to those of their nearest conspecific neighbors (mean = 2.65 m) were greater than distances to nests of Cattle Egret neighbors (mean = 1.5 m). Although nest success was not significantly different as a result of distance to nearest neighbors, of the 49 successful nests, 16 with neighbors within 1 m

produced 21 fledglings (mean = 1.31/nest) whereas 33 nests with distant neighbors, produced 54 fledglings (mean = 1.64/nest).

NESTLING GROWTH AND DEVELOPMENT

I collected 383 measurements from a total of 92 chicks in 84 nests in 1994 and 1995. Each year I measured exposed culmen length, forearm length, tarsus length, and mass on alternate days until chicks disappeared, died, or were no longer accessible. The two oldest chicks measured were 20 days old.

Comparisons of chick sizes indicate that chicks grew at comparable rates regardless of brood size or whether they survived or died. However, chick sizes were slightly different as a function of year and hatching asynchrony. These data indicate that mortality resulted from factors (predation) unrelated to food resources, and that parental skills at collecting and delivering food to the nestlings were similar in both years.

Growth of each measured parameter followed a sigmoidal (S-shaped) growth curve. Initially small increases through day 2 were followed by rapid growth through day 15, at which time growth slowed as chicks approached adult sizes.

The tarsus developed the most rapidly, perhaps enabling a nestling to escape predators, while the culmen

grew the slowest, possibly an adaptation to enhance food transfer.

In a comparison of sizes between Louisiana chicks and Utah chicks, I found that Louisiana chicks were larger on day 20, suggesting that food in Louisiana may be more abundant or the milder weather may be more conducive to foraging.

An analysis of undigested food pellets regurgitated by nestlings revealed the presence of one or two primary foods in each pellet: water bugs, horsefly larvae, beetles, and dragonfly larvae. One pellet contained mostly plant material. Beetles (Coleoptera), found in every pellet, were the most common food item. Although White-faced Ibises are reputed to consume crawfish *(Procambarus clarkii)*, I found no evidence of crawfish in any of the pellets, and, furthermore, I found no crawfish remnants in or around nests during the 2 years of my study.

LITERATURE CITED

Aldous, S.E. 1944. A deer browse survey method. J. Mammal. 25(2):130-136.

Cottam, G., and J.T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecology 37(3):451-460.

Cottam, G., J.T. Curtis, and B.W. Hale. 1953. Some sampling characteristics of a population of randomly dispersed individuals. Ecology 34(4):741-757.

Lack, D. 1947. The significance of clutch-size, I-II. Ibis 89:302-352.

Lack, D. 1948. The significance of clutch-size, III. Ibis 90:25-45.

Lack, D. 1954. The natural regulation of animal numbers. Methuen Books, Oxford, England.

Mayfield, H.F. 1961. Nesting success calculated from exposure. Wilson Bull. 73:255-261.

Mayfield, H.F. 1975. Suggestions for calculating nest success. Wilson Bull. 87:456-466.

Ryder, R.A. 1967. Distribution, migration and mortality of the White-faced Ibis (Plegadis chihi) in North America. Birdbanding 38:257-277.

OVERSTORY VEGETATION FORMULAS

1. Diameter at breast height (dbh) = (Circumference) (0.3183)

2. Relative density for any taxon(%) = $\frac{\text{No. of individuals of taxon}}{\text{Total no. of individuals}}$

3. Relative dominance for any taxon(%) = $\frac{\text{Total basal area of taxon}}{\text{Total basal area of all basal areas}}$

4. No. of trees of any taxon per hectare

   A. Average distance to tree from center point ("Spacing") = $\frac{\text{Total of all distances in sample}}{\text{Total number of distances}}$

   B. Average area occupied per tree in m^2 = (Average distance per tree)^2

   C. Number of trees per hectare = $\frac{\text{10,000 } m^2 \text{ per hectare}}{\text{Avg. area occupied per tree}}$

   D. No. of trees of any taxon per hectare = (Rel. density of a taxon) (Number of trees per hectare)

D. No. of trees of any taxon per hectare = (Rel. density of a taxon) (Number of trees per hectare)

5. Basal area per hectare

A. BA per tree = $\frac{\text{Total of all BA}}{\text{Total no. of trees}}$

B. BA per hectare = (Avg BA per tree) (No. of trees per hectare)

6. BA per hectare of any taxon = (Rel. dominance of taxon) (Tot. BA per hectare)

UNDERSTORY VEGETATION FORMULAS

1. Frequency of a taxon = $\frac{\text{No. of plots in which taxon occurred}}{\text{Total no. plots in sample}}$

2. Average cover of a taxon = $\frac{\text{Total of all cover values for the taxon}}{\text{Total no. of plots in sample}}$

3. Percent a taxon composes of total vegetation = $\frac{\text{Average cover of the taxon}}{\text{Total of average cover values of all taxa}}$

VITA

Kathleen C. Garrett was born on September 6, 1947 in Camden, New Jersey to Jean T. and Joseph R. Carson. She graduated from Moorestown High School, Moorestown, New Jersey, in 1965. She received a Bachelor of Science degree in Psychology and Social Studies from Ursinus College, Collegeville, Pennsylvania in 1969. Upon graduation she joined the U.S. Peace Corps and served as a teacher in Sierra Leone, West Africa.

In 1976, while serving as a program manager for the U.S. Environmental Protection Agency, she received a Master of Science degree in Technology of Management (majoring in Environmental Resources Management) from American University, Washington, D.C.

She served as Director of Wildlife Programs for a non-profit environmental conservation organization before entering graduate school at Louisiana State University in August, 1992. Currently she is a candidate for the degree of Doctor of Philosophy in Wildlife and Fisheries Science.

DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Kathleen Carson Garrett

Major Field: Wildlife and Fisheries Science

Title of Dissertation: Nesting Ecology of the White-faced Ibis (Plegadis chihi) in Southwestern Louisiana

Approved:

Robert B. Hamilton
Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination:

22 March 1996